

American National Standard
for Telecommunications –

Integrated Services Digital Network (ISDN) – Performance Parameters and Objectives

1 Purpose and scope

The purpose of this standard is to define a comprehensive basis for assessing the performance of Integrated Services Digital Networks (ISDNs) providing telecommunication service in accordance with the American National Standards and ITU-T Recommendations identified herein. This standard:

(a) defines parameters that may be used to describe the performance of ISDN bearer services and (b) specifies worst-case objectives for the ISDN performance parameters. The parameters and objectives are applicable to circuit mode and packet mode ISDN bearer services. Unless noted otherwise in this standard, the defined parameters and specified objectives apply to ISDN services using a single B channel and/or D channel; planned revisions to this standard will address other ISDN bearer services (e.g., $n \times 64$ kbit/s). Practical methods for measuring ISDN parameter values will be specified in a planned supplement to this standard.

For each ISDN bearer service, performance is considered in the context of the 3×3 performance matrix defined in *American National Standard for Information systems – Data communication systems and services – User-oriented performance parameters*, ANSI X3.102-1992 (see figure 1). Three protocol-independent data communication functions are identified in the matrix: access, user information transfer, and disengagement. Each function is considered with respect to three general performance concerns (or "performance criteria"): speed, accuracy, and dependability. This standard defines a comprehensive set of primary parameters that describe performance relative to each function and criterion. The objectives specified for the primary parameters apply only to connections in the available state. A two-state model provides a basis for describing overall service availability. A specified availability function compares the values for a set of "supported" primary parameters with corresponding outage thresholds to classify the service as "available" (no service outage) or "unavailable" (service outage). This standard specifies the availability function and defines the availability parameters that characterize the resulting binary random process.

The parameters defined in this standard may be used to specify or measure the performance of end-to-end ISDN connections or connection portions. This standard defines two general ISDN connection portion types: access portions and transit portions. These portions are delimited on the basis of jurisdictional boundaries between carriers and corresponding jurisdictional boundaries between carrier facilities and customer premises equipment. This standard defines worst-case objectives for each portion type. The measurement methods that will be defined in a supplement to this standard will be applicable in direct measurements at the defined jurisdictional boundaries or may be used to estimate performance at jurisdictional boundaries on the basis of observations made at adjunct functional boundaries (e.g., switch locations), taking account of known characteristics of the access or transit links that connect equipment in separate jurisdictions.

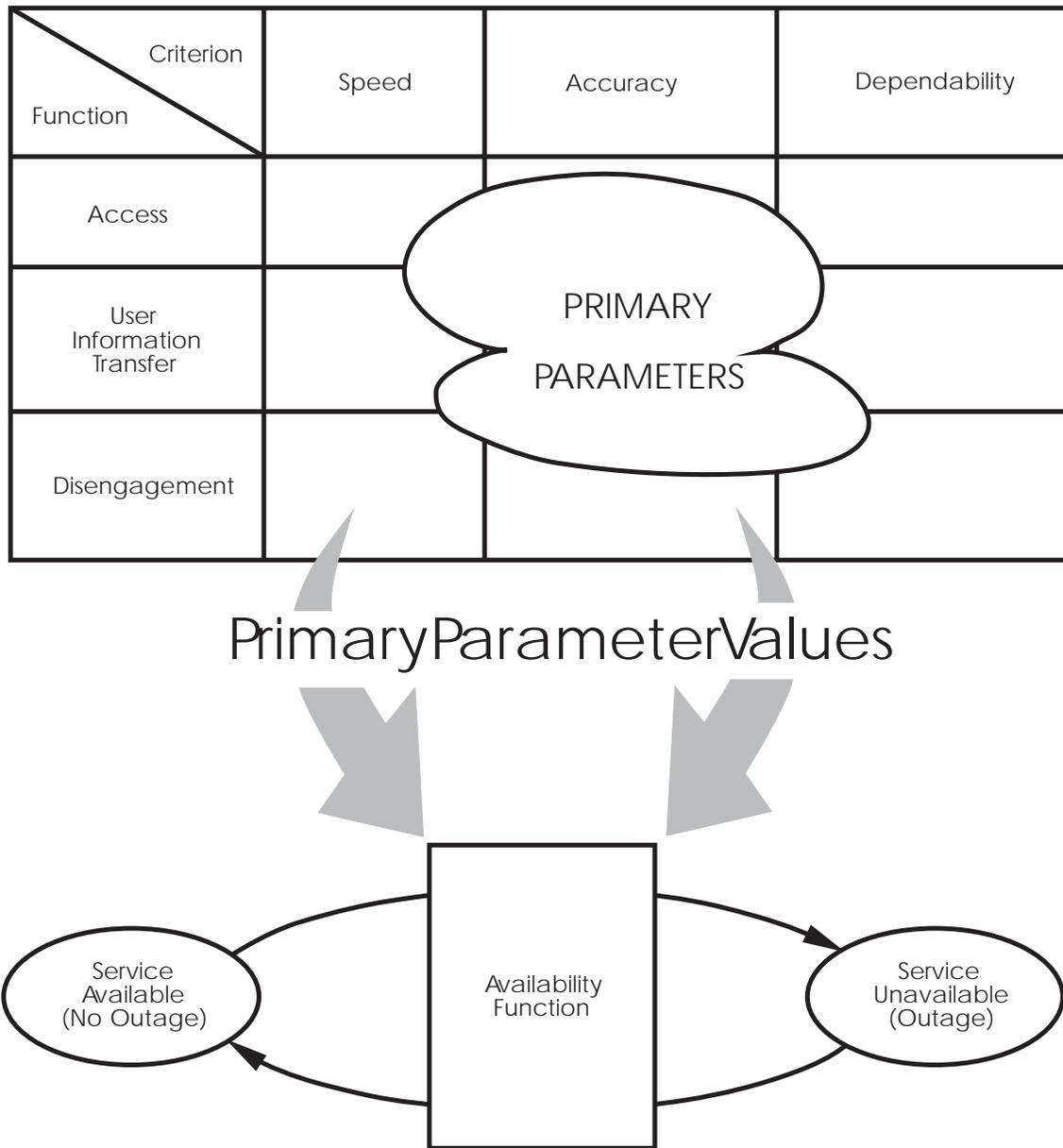


Figure 1 - 3 x 3 performance matrix framework

Figure 1 – 3 x 3 performance matrix framework

All values specified in this standard (with the exception of table 14) are based on (and only apply under) the following assumptions:

- values for primary performance parameters exclude performance observed during periods of unavailability;
- for each connection portion type, the ten worst-performing days in a calendar year are excluded.

In the context of this standard, the term, *worst-case*, means that the design objectives should be met by all portions of any end-to-end connection configured and used in accordance with the conditions and assumptions identified in this standard.

The design objectives specified in this standard may not be achievable in all network configurations existing at the time of its publication. They represent agreements among service providers and end users applicable to the planned evolution of ISDN bearer services and their interconnection. The actual values achieved in a connection portion will depend on many factors, including the traffic expected and actually offered, the internal network topology, and the signalling rates on the access and internetwork circuit sections. Variation away from the worst-case value for each factor can improve performance.

In some cases, two sets of values are specified for access portions depending on their interconnection to the transit portion. One set of values applies when the access portion is nominally interconnected to the transit portion. The other set applies when the access and transit portion providers cooperatively plan the interconnection. These two sets of values are called nominal interconnection values and cooperatively planned interconnection values, respectively. An example of a cooperatively planned interconnection is one that reduces the number of switches between the NI and the INI.

The organization of this standard is summarized in figure 2. Clause 2 identifies the normative references. Clause 3 defines an ISDN performance model that (a) specifies the boundaries and connection portion types and (b) defines a set of protocol-specific reference events that provide a basis for performance parameter definition. Clauses 4 and 5 provide a basis for performance assessment of ISDN circuit mode bearer services and packet mode bearer services, respectively. These clauses define protocol-specific performance parameters and specify worst-case performance objectives. Annex A provides a bibliography.

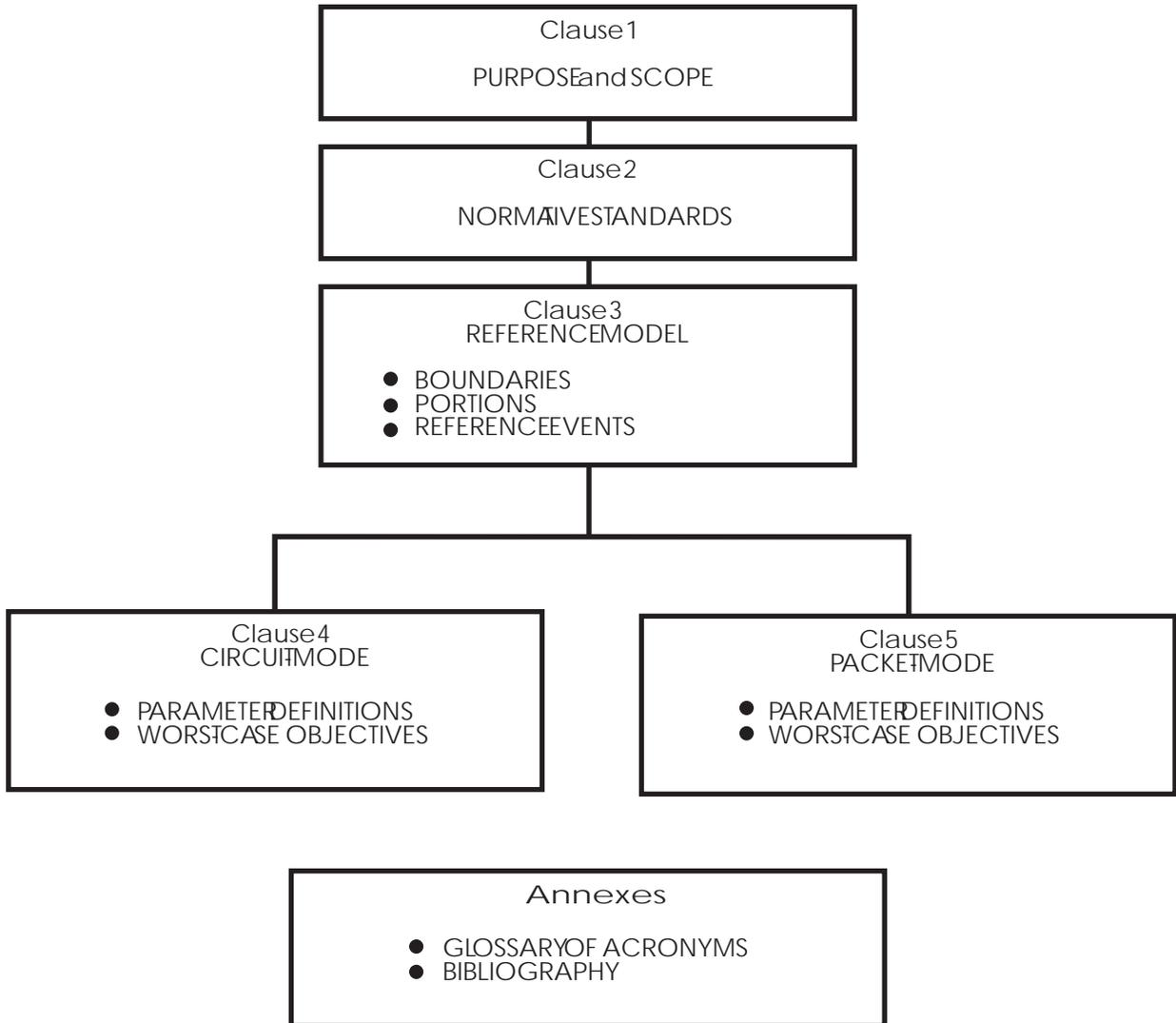


Figure 2 - Organization of T1.51
Figure 2 – Organization of ANSI T1.517-1995

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ANSI T1.113-1995, *Telecommunications – Signalling system no. 7 (SS7) – Integrated services digital network (ISDN) user part*

ANSI T1.403-1995, *Telecommunications – Network-to-customer installation – DS1 metallic interface*

ANSI T1.504-1989, *Telecommunications – Packet-switched data communication service – Performance parameters*

ANSI T1.504a-1991, *Telecommunications – Packet-switched data communication service – Performance measurement methods*

ANSI T1.504b-1993, *Telecommunications – Packet-switched data communication service – Performance objectives*

ANSI T1.602-1989, *Telecommunications – Integrated services digital network (ISDN) – Data-link layer signalling specification for application at the user-network interface*

ANSI T1.607-1990, *Telecommunications – Integrated services digital network (ISDN) – Layer 3 signaling specification for circuit-switched bearer service for digital subscriber signaling system number 1 (DSS1)*

ANSI T1.608-1991, *Telecommunications – Integrated services digital network (ISDN) – Signaling specification for X.25 Packet-switched bearer service for digital subscriber signaling system number 1 (DSS1)*

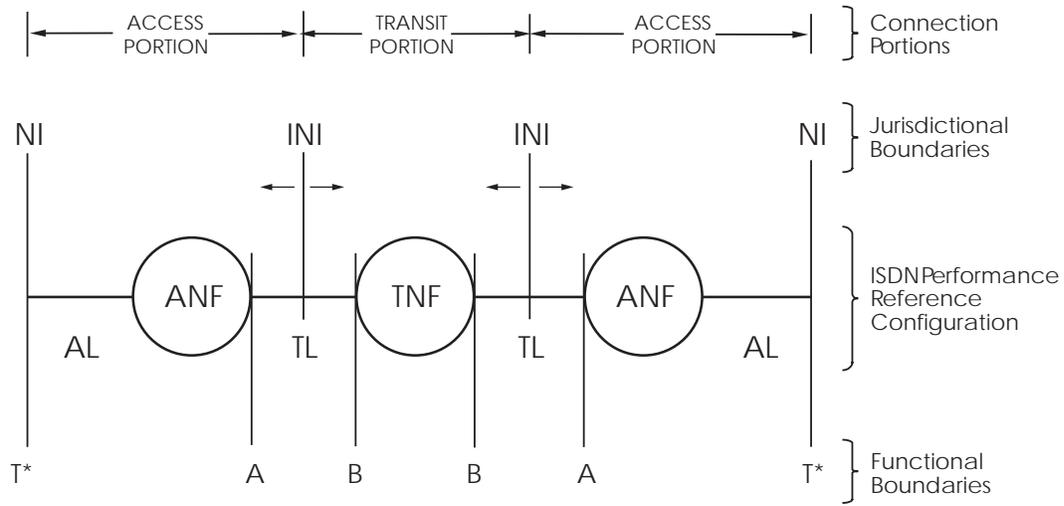
ANSI T1.608a-1992, *Telecommunications – Integrated services digital network (ISDN) – Signaling specification for X.25 Packet-switched bearer service for digital subscriber signaling system number 1 (DSS1) (Terminal initialization procedures for packet mode data)* [Part of ANSI T1.608-1991]

ANSI T1.614-1991, *Telecommunications – Integrated services digital network (ISDN) – Packet mode bearer service category description*

3 Performance model

This clause of the standard defines an ISDN performance model that provides a basis for ISDN performance parameter definition. The ISDN performance model comprises an ISDN reference configuration, jurisdictional boundaries, and associated access and transit connection portions, and a set of performance-significant reference events (see figure 3). To facilitate parameter definition, the connection portions are subdivided into network fabrics and links. A representative end-to-end national ISDN connection consists of two access portions and an intervening transit portion. Although other jurisdictional arrangements are possible, an access portion is generally comprised of facilities provided by an "exchange carrier" and a transit portion is generally comprised of facilities provided by an "inter-exchange carrier." Worst-case performance objectives are specified for the access and transit portions.

Direct measurement of performance at the defined jurisdictional boundaries will not always be practical. This standard defines functional boundaries that may serve as practical surrogates for the jurisdictional boundaries. The standard establishes guidelines for estimating the performance of jurisdictional portions on the basis of measurements taken at the functional boundaries.



LEGEND

NI = Network Interface
 INI = Internetwork Interface
 TL = Transit Link
 AL = Access Link

ANF = Access Network Fabric
 TNF = Transit Network Fabric
 T, A, B = Functional Boundaries

NOTE - * Reference point T may be coincident with the NI or may be created at the NI by an attached NT1

Figure 3 - Provisional national ISDN performance allocation model

Figure 3 – Provisional national ISDN performance allocation model

3.1 Definitions

In the context of this standard, the following definitions apply:

3.1.1 network interface (NI): The NI is the jurisdictional boundary between the customer's installation and the network provider's equipment. This standard uses the NI boundaries to allocate ISDN performance responsibilities between the customers and the network service providers. The ISDN T reference point, which separates the NT1 and TE (or NT2) functions is considered coincident with the NI for measurement purposes (see 3.2).

3.1.2 internetwork interface (INI): The INI is the jurisdictional boundary between the access network provider's and transit network provider's equipment. This standard uses the INI boundaries to allocate ISDN performance responsibilities among the access network and transit network service providers.

3.1.3 access portion: The access portion is the portion of an end-to-end ISDN connection between a network interface and the closest internetwork interface. An access portion carries user information and signaling information between the network and internetwork interfaces. An access portion typically includes an access link and an access network fabric.

3.1.4 transit portion: The transit portion is the portion of an end-to-end ISDN connection between the two internetwork interfaces. The transit portion carries user information and signaling information between the two INIs. A transit portion normally includes a transit network fabric.

3.1.5 access link (AL): An AL is a physical circuit or set of circuits connecting an NI to a switching function. An AL transports user information and signaling information.

3.1.6 transit link (TL): A TL is a physical circuit or set of circuits connecting a switching function or signaling node in one jurisdiction with a switching function or signaling node in another jurisdiction.

3.1.6.1 transit link – access component: That component of the TL within the access portion.

3.1.6.2 transit link – transit component: That component of the TL within the transit portion.

3.1.7 access network fabric (ANF): An ANF consists of network components that route user information and signaling information between an access link and one or more transit links.

3.1.8 transit network fabric (TNF): The TNF consists of the network components that route user information and signaling information between two sets of transit links.

3.1.9 functional boundaries (T, A, B): The functional boundaries, (denoted T, A, and B) represent locations in the ISDN reference configuration where practical performance measurements can be made. The functional boundary T refers to the ISDN T reference point (see clause 2 and annex A) that separates the NT1 and TE (or NT2) functions. The functional boundaries A and B refer to the network locations where the transit link is terminated (e.g., switch locations). There are two functional boundaries associated with a jurisdictional INI.

3.1.9.1 associated upstream functional boundary: The associated upstream functional boundary is the functional boundary nearest the INI from which the relevant function request is emanating.

3.1.9.2 associated downstream functional boundary: The associated downstream functional boundary is the functional boundary nearest the INI toward which the relevant function request is destined.

3.1.10 Acronyms

AL	Access link
ANF	Access network fabric
ANSI	American National Standards Institute
CEP	Connection set-up error probability
CFP	Connection set-up failure probability
ES	Errored second
FFS	For further study
I	Information
INI	Internetwork interface
ISDN	Integrated Services Digital Network
ITU-T	International Telecommunication Union-Telecommunication Standardization Sector
LAPB	Link access protocol balanced
LAPD	Link access protocol D-channel
MTBSO	Mean time between service outages
MTTSR	Mean time to service restoral
NE	Network element
NI	Network interface
NT	Network termination
PD	Premature disconnect
PDEP	Premature disconnect event probability
PDS	Premature disconnect stimulus
PDSP	Premature disconnect stimulus probability
PH	Packet handler
PSTN	Public switched telephone network
RE	Reference event
SA	Service availability
SABME	Set asynchronous balanced mode extended
SES	Severely errored second
SF	Switching function
SN	Switching node
SS7	Signaling System 7
T	ISDN T reference point
TE	Terminal equipment
TL	Transit link
TNF	Transit network fabric
U	Unavailability
UA	Unnumbered acknowledgement
UI	Unnumbered information

NOTE – Acronyms are also identified in the tables and figures in which they are used.

3.2 Reference event concepts

In the context of this standard, a reference event occurs when a relevant unit of information crosses a relevant boundary in a predetermined direction. Reference events are specified by identifying the following three attributes:

- *Relevant boundary*: Reference events are defined to occur at both jurisdictional and functional boundaries.
- *Unit of information transferred*: Two general categories of transferred information are distinguished: control information and user information.

– *Reference event class*: Two classes of reference events are distinguished: exit events and entry events. When evaluating performance at a jurisdictional boundary (NI or INI), the words *exit* and *entry* always refer to exit from or entry into a (hypothetical) test device facing the portion(s) under test (figure 4). When evaluating performance at a functional boundary (T, A, or B), the words *exit* and *entry* always refer to exit from or entry into a TE, SF, or SN along an access or transit link (figure 5).

The *time of occurrence of an exit event* is defined to coincide with the time at which the first bit of the unit of control or user information creating the exit event crosses the relevant boundary. The *time of occurrence of an entry event* is defined to coincide with the time at which the last bit of the unit of control or user information creating an entry event crosses the relevant boundary. If retransmissions occur on the local link, the exit event occurs with the first transmission and the entry event occurs with the last transmission on the link.

Figure 6 illustrates a practical method for estimating performance at the NI boundary from measurements made at the T boundary. There are two cases that must be considered to reconcile the NI and T performance boundaries. Case 1 is where the NI boundary and the T boundaries coincide; in this case performance measurement can be performed by placing the devices that provide ISDN terminal equipment (TE) functionality at the NI boundary. Case 2 is where the NI boundary and the T boundary do not coincide; in this case by attaching a device that provides physical layer ISDN network termination (i.e., NT1) nominal functionality at the NI boundary, the NI boundary and the T boundary can be considered to be coincident for performance measurement purposes.

3.3 Performance-significant reference events

Performance-significant reference events are reference events useful in defining performance parameters. Table 1 provides references to information, either in this standard or in other standards, that collectively define a relevant set of ISDN performance-significant reference events.

Table 1 – References to standards specifying ISDN performance-significant reference events

Protocol	Relevant boundary	
	NI/T	INI/A/B
ANSI T1.607	ANSI T1.517, 3.3.1	N/A
ANSI T1.602	ANSI T1.517, 3.3.2	N/A
ITU-T Recommendation X.25 layer 3	ANSI T1.504, ANSI T1.504b	N/A
ITU-T Recommendation X.25 layer 2 (LAPB)	ANSI T1.517, 3.3.3	N/A
ITU-T Recommendation X.75	N/A	ANSI T1.504, ANSI T1.504b
ANSI T1.113	N/A	ANSI T1.517, 3.3.4
ANSI T1.403 (circuit mode)	ANSI T1.517, 3.3.5	ANSI T1.517, 3.3.5
NOTE – N/A indicates that the protocol is not applicable at the particular boundary.		

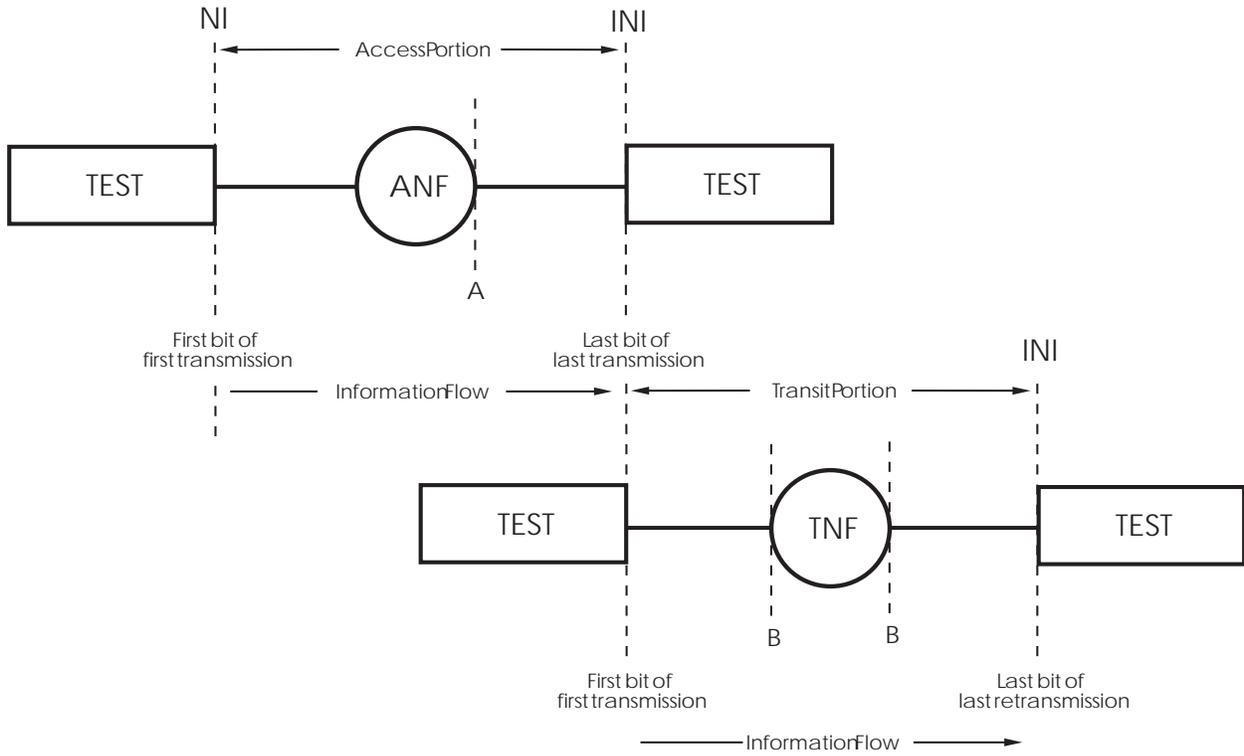
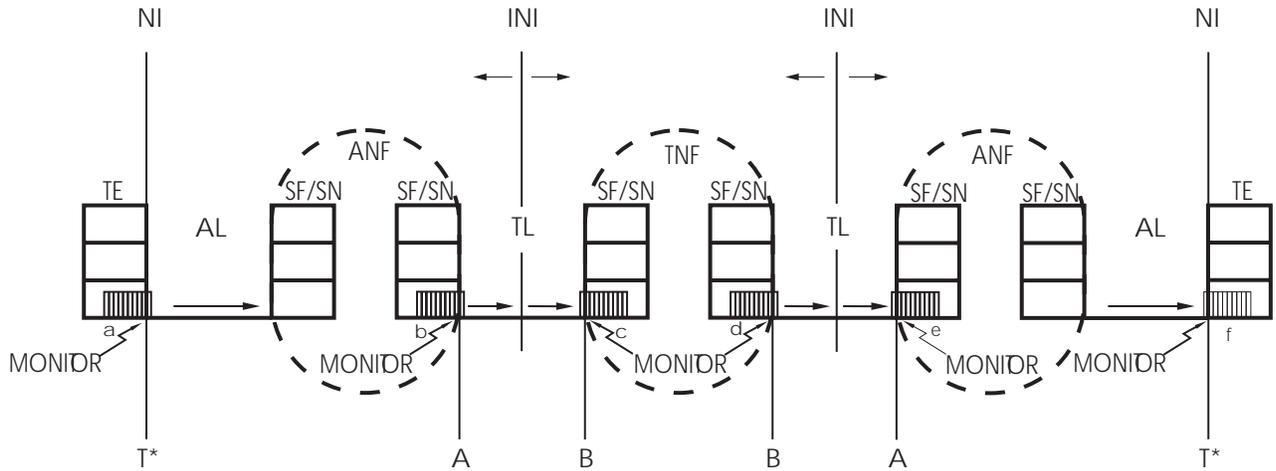


Figure 4 - Definition of reference events (REs) at the NI and INI boundaries

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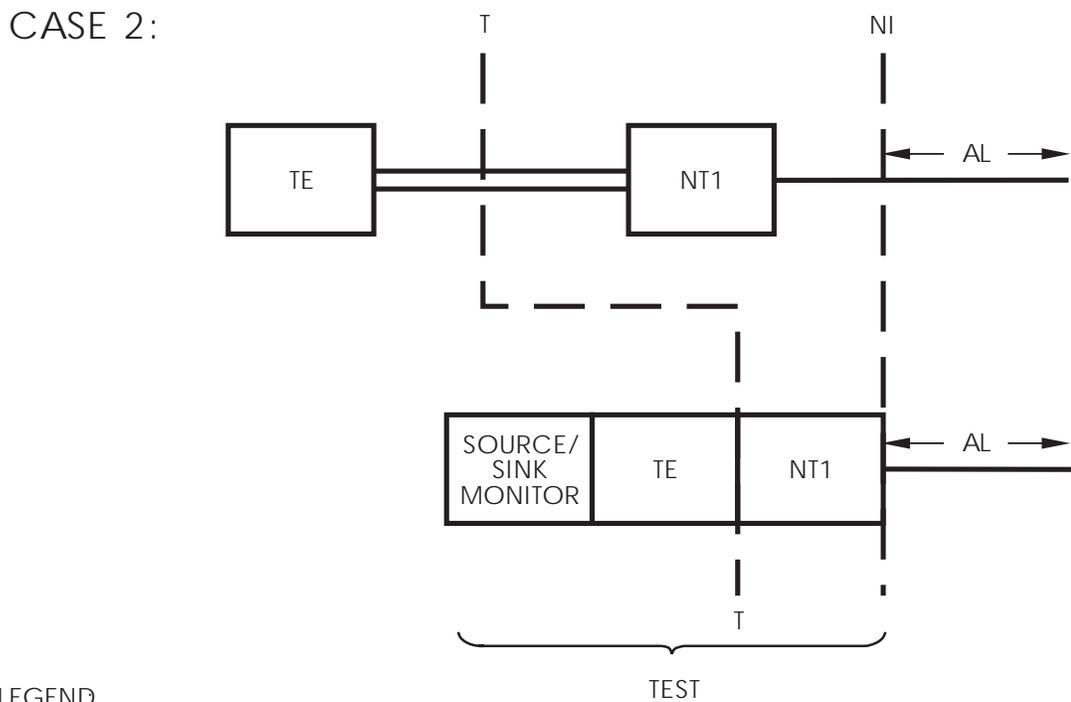
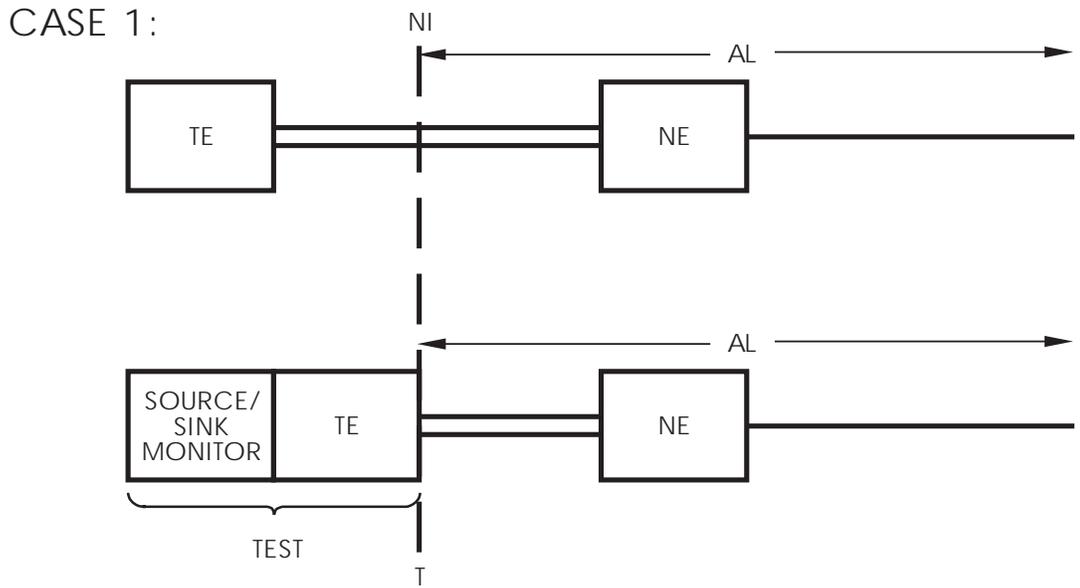


SF = SwitchingFunction
 SN = SignalingNode

Exit events for information units a, b, d
 Entry events for information units c, e, f

NOTE - Reference point T may be coincident with the NI or may be created at the NI by an attached NT1.

Figure 5 - Example entry and exit reference events
Figure 5 – Example entry and exit reference events



LEGEND

- AL = Access Link
- TE = Terminal Equipment function
- NT = Network Termination function
- NE = Network Element
- NI = Network Interface
- T = T reference point
- TEST = Test function

Figure 6 - Reconciling the NI and T performance boundaries
Figure 6 – Reconciling the NI and T performance boundaries

3.3.1 ANSI T1.607

Table 2 lists performance-significant ANSI T1.607 message transfer reference events associated with the NI/T boundary. Each code ends in either an "a" or "b". All codes that end in an "a" represent exit reference events that have a flow of user to network (u – n), and all codes that end in a "b" represent entry reference events that have a flow of network to user (n – u). The unit of information used in defining the time of occurrence of these reference events is the layer 2 frame that carries the layer 3 message across the relevant boundary.

**Table 2 – ISDN performance-significant reference events (REs)
based on ANSI T1.607 layer 3 message transfer at the NI/T boundary**

RE code	Layer 3 message	
P1	a	SETUP (S)
	b	SETUP (S)
P2	a	SETUP ACKnowledge (SA)
	b	SETUP ACKnowledge (SA)
P3		INFOrmation (I)
P4	a	CALL PROCeeding (CP)
	b	CALL PROCeeding (CP)
P5	a	ALERTing (A)
	b	ALERTing (A)
P6	a	CONNect (C)
	b	CONNect (C)
P7		CONNect ACKnowledge (CA)
P8	a	DISConnect (D)
	b	DISConnect (D)
P9		RELease (R)
P10		RELease COMplete (RC)

3.3.2 ANSI T1.602

Table 3 lists performance-significant ANSI T1.602 frame transfer reference events associated with the NI/T boundary. The table entries are: event identification code and type of layer 2 frame transferred. The unit of information used in defining the time of occurrence of layer 2 exit and entry reference events is the layer 2 frame.

Table 3 – ISDN performance-significant reference events (REs) based on ANSI T1.602 layer 2 frame transfer at the NI/T boundary

RE code		Layer 2 frame
Q1	a	I
	b	I
Q2		RR
Q3		RNR
Q4		REJ
Q5		SABME
Q6		DM
Q7		UI
Q8		DISC
Q9	a	UA
	b	UA
Q10		FRMR
<p>NOTES</p> <p>1 Notation: I=Information, RR=Receive Ready, RNR=Receive Not Ready, REJ=Reject, SABME=Set Asynchronous Balanced Mode Extended, DM=Disconnect Mode, UI=Unnumbered Information, DISC=Disconnect, UA=Unnumbered Acknowledgment, FRMR=Frame Reject.</p> <p>2 Exchange Identification (XID) frames have no effect on the operational mode associated with data link layer entities.</p>		

3.3.3 ITU-T Recommendation X.25

Table 4 lists performance-significant X.25 layer 2 (LAPB) frame transfer reference events associated with the NI/T boundary. The table entries are: event identification code and type of X.25 layer 2 (LAPB) frame transferred. The unit of information used in defining the time of occurrence of X.25 layer 2 exit and entry reference events is the layer 2 frame.

Table 4 – ISDN performance-significant reference events (REs) based on ITU-T Recommendation X.25 layer 2 (LAPB) frame transfer at the NI/T boundary

RE code		Layer 2 frame
B1	a	I
	b	I
B2		RR
B3		RNR
B4		REJ
B5		SABM
B6		SABME
B7		DM
B8		DISC
B9 ¹⁾	a	UA
	b	UA
B10		FRMR

¹⁾ B9a occurs in response to an SABM or SABME command. B9b occurs in response to a DISC command.

NOTE – Notation: I=Information, RR=Receive Ready, RNR=Receive Not Ready, REJ=Reject, SABM=Set Asynchronous Balanced Mode, SABME=Set Asynchronous Balanced Mode Extended, DM=Disconnect Mode, DISC=Disconnect, UA=Unnumbered Acknowledgment, FRMR=Frame Reject.

3.3.4 ANSI T1.113

Table 5 lists performance-significant ANSI T1.113 message transfer reference events associated with the INI/A/B boundary. Each code ends in either an "a" or "b". All codes that end in an "a" represent exit reference events and those codes that end in a "b" represent entry reference events. The unit of information used in defining the time of occurrence of these reference events is the layer 2 frame that carries the layer 3 message across the relevant boundary.

Table 5 – ISDN performance-significant reference events (REs) based on ANSI T1.113 message transfer at the INI/A/B boundary

RE code	ANSI T1.113 message
S1	a Initial Address (IAM)
	b Initial Address (IAM)
S2	a Address Complete (ACM)
	b Address Complete (ACM)
S3	a Answer (ANM)
	b Answer (ANM)
S4	a Release (REL)
	b Release (REL)
S5	Release Complete (RLC)
S6	a Circuit RESET
	b Circuit RESET
S7	a RESET
	b RESET

3.3.5 ANSI T1.403 (circuit mode)

This subclause defines performance-significant reference events that may be used to define user information transfer parameters for ISDN circuit mode bearer services.

3.3.5.1 Circuit mode performance-significant reference events

A performance-significant reference event for circuit mode unrestricted digital bearer services is the appearance of a relevant user information bit at a relevant boundary. The relevant boundary is the measurement point where performance is to be quantified. The unit of information transferred is one bit of user information.

3.3.5.2 The relevant bit of user information

The ability to identify the relevant bit of user information is essential to the definition of the user information transfer parameters. Unrestricted digital bearer services accept a sequence of bits $\{a_i\}$ at one relevant boundary and deliver a sequence of bits $\{b_j\}$ at another relevant boundary. When measuring information transfer performance between those two boundaries, the relevant bits are usually "corresponding" bits in the two sequences. The term, *corresponding*, has meaning if and only if there exists a large integer N and other integers m and d such that:

$$a_i = b_{i+d}, \text{ for almost all integers } i, m = i = m + N, \quad (1)$$

where:

m is the index of the first bit in a sequence of N bits, and

d is the displacement in the index at the output boundary.

Then, for all i , $m = i = m + N$, bit b_{i+d} is said to *correspond* to bit a_i .

When the corresponding bits a_i and b_{i+d} are not equal, the bit b_{i+d} is said to have been *errored* between the boundaries. When the corresponding bits a_i and b_{i+d} are equal, the bit b_{i+d} is said to be *unerrored*.

Before counting errored and unerrored bits in user information transfer measurement results, it is advisable to adjust m , d , and N in a way that maximizes N . However, m , d , and N should also be chosen so that (a) bit b_{i+d} corresponds to bit a_i (i.e., equation (1) holds) and (b) the large majority of bits at both the beginning and the end of the sequence $\{b_{m+d}, \dots, b_{m+N+d}\}$ are unerrored.

If there are no m , d , and large N for which equation (1) holds, the condition is referred to as *failure to synchronize*, or *no synch*. A period of no signal or failure to synchronize shall be considered a period of errored bits.

4 Circuit mode ISDN bearer services

This clause defines performance parameters and specifies associated worst-case performance objectives for unrestricted digital connection types provided using ISDN circuit mode bearer services. Availability decision parameters and associated worst-case performance objectives for circuit mode ISDN bearer services are defined in clause 4. Performance-related definitions for ISDN terminal equipment are not specified; however, the parameters defined in this clause may be employed in such definitions to assist users in establishing relationships between network performance and quality of service.

4.1 Speed of service parameters and objectives

This subclause specifies for circuit mode ISDN bearer services delay parameters that can be measured or estimated between any pair of boundaries delimiting a portion or concatenation of portions.

4.1.1 Connection set-up delay

Connection set-up delay applies to ISDN switched connection types. This parameter is used to measure the speed of the general function of access in public ISDN switched services conforming to the standards identified in clause 2.

4.1.1.1 Definition of connection set-up delay

Connection set-up delay is defined first based on observations at a single portion boundary and then based on observations at two portion boundaries. In the former case, the connection set-up delay includes the delay for all portions on the called user side of the boundary, including the TE. In the latter case, the connection set-up delay includes only the delay between the portion boundaries. The overall connection set-up delay is shown in figure 7.¹⁾

4.1.1.1.1 Definition of connection set-up delay observed at a single portion boundary

Connection set-up delay at a single portion boundary, B_j , is defined using two connection processing reference events. Connection set-up delay is the length of time that starts when a SETUP or the last address information message creates a reference event at B_j and ends when the corresponding CONNECT message returns and creates its reference event at B_j .

$$\text{Connection set-up delay observed at a single portion boundary} = t_2 - t_1,$$

where:

t_1 is the time of occurrence of the starting reference event;

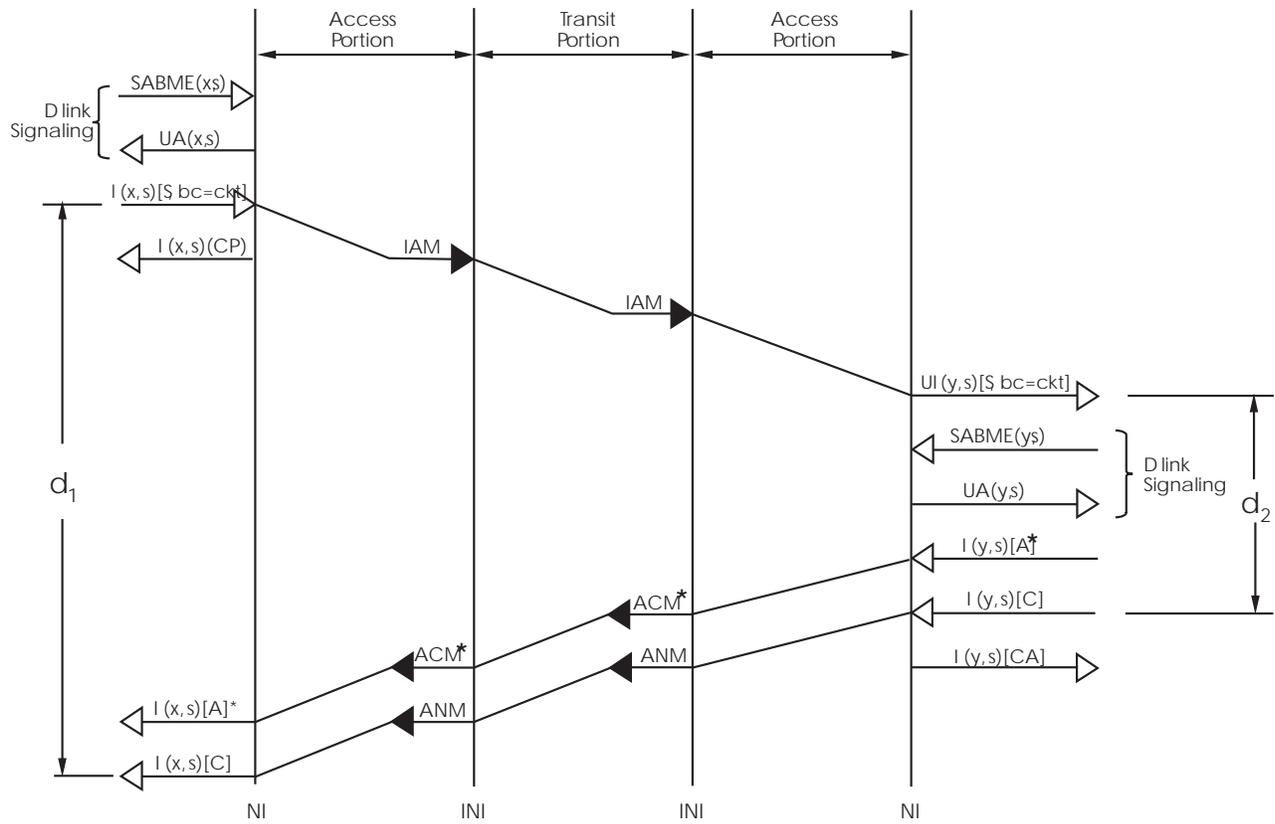
t_2 is the time of occurrence of the ending reference event.

The ANSI T1.607, ANSI T1.602, and ANSI T1.113 messages associated with connection set-up are shown in figure 7. The specific reference events used in measuring connection set-up delay at a single boundary are shown in table 6a.

Table 6a – Reference events (REs) defining ISDN circuit mode connection set-up delay at a single boundary, B_j

Boundary, B_j	Starting RE	Ending RE
Originating NI/T	P1a (en bloc) (SETUP exit)	P6b (CONNECT entry)
INI jurisdictional boundary	S1a (IAM exit)	S3b (ANSWER entry)
Associated upstream functional boundary	S1a (IAM exit)	S3b (ANSWER entry)
Associated downstream functional boundary	S1b (IAM entry)	S3a (ANSWER exit)
Answering NI/T	P1b (SETUP entry)	P6a (CONNECT exit)
NOTE – En bloc and overlap sending options are defined at the calling NI/T interface.		

¹⁾ Abbreviations used to identify reference events in figure 7 and subsequent figures are defined in tables 2–5. Parentheses () denote data link layer addresses; (A) and (B) for LAPB and (TEI, SAPI) pairs for LAPD. The signaling SAPI is denoted by s and the packet SAPI is denoted by p. Symbols in brackets [] identify ANSI T1.607 messages carried in the indicated frame. For ANSI T1.607 SETUP messages, circuit mode and packet mode bearer services are identified by bc=ckt and bc=pkt, respectively.



NOTE - * required if voice call

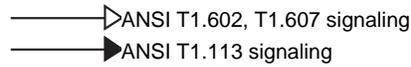


Figure 8 - Circuit mode: Overall connection set-up delay

Figure 7 – Circuit mode: Overall set-up delay

4.1.1.1.2 Definition of connection set-up delay between two portion boundaries

The connection set-up delay can be measured at one portion boundary, B_i , and at a downstream boundary, B_j , farther from the calling party. The difference in the values obtained is the connection set-up delay contributed by the portions between the two boundaries.

$$\text{Connection set-up delay between two portion boundaries} = d_i - d_j,$$

where:

d_i is the connection set-up delay measured at B_i ;

d_j is the connection set-up delay measured at B_j .

The reference events used in measuring d_i at the upstream boundary B_i are selected using table 6a. When measuring d_j , the reference events at the downstream boundary B_j are selected using table 6b.

Table 6b – Reference events (REs) defining ISDN circuit mode connection set-up delay at the downstream functional boundary, B_j

Boundary, B_j	Starting RE	Ending RE
Originating NI/T	Not Applicable	Not Applicable
INI jurisdictional boundary	S1b (IAM entry)	S3a (ANSWER exit)
Associated upstream functional boundary	S1a (IAM exit)	S3b (ANSWER entry)
Associated downstream functional boundary	S1b (IAM entry)	S3a (ANSWER exit)
Answering NI/T	P1b (SETUP entry)	P6a (CONNECT exit)
NOTE – En bloc and overlap sending options are defined at the calling NI/T interface.		

The end-to-end connection set-up delay is the connection set-up delay between the two NI/T boundaries. This delay (shown as $d_1 - d_2$ in figure 7) excludes the called user response time. The connection set-up delay for a portion is the connection set-up delay between the two boundaries delimiting that portion.

4.1.1.2 Connection set-up delay objectives

Table 7 specifies ISDN circuit mode connection set-up delay objectives for each of the portion types defined in 3.1. All values are based on (and only apply under) the following assumptions:

- basic call in which the SETUP message contains no optional information elements;
- en bloc sending used;
- data link layer windows of entities outside the portion being specified are open (not flow controlled);
- no interworking with non-ISDN networks.

**Table 7 – Worst-case performance objectives
for ISDN circuit mode connection set-up delay**

ISDN Connection Type	Portion type	Statistic	
		Mean (ms)	95% (ms)
64 kbit/s unrestricted switched	Access	1195	FFS
	Transit	1600	FFS
NOTES 1 If a satellite link is used in a connection portion, the performance objective for that portion should be increased by 600 ms. 2 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.			

4.1.2 Disconnect delay

Disconnect delay applies to ISDN switched connection types. This parameter is used to measure the speed of the general function of disengagement in public ISDN switched services conforming to the standards identified in clause 2.

4.1.2.1 Definition of disconnect delay between two portion boundaries

Disconnect delay is based only on a one-way message transport from the clearing party to the cleared party as shown in figure 8 (see footnote 1). Therefore, this parameter requires observations at two connection element boundaries.

Disconnect delay between two portion boundaries, B_i and B_j , is defined as the length of time that starts when a DISConnect message creates a reference event at B_i and ends when that DISConnect message creates a reference event at B_j , farther from the clearing party.

$$\text{Disconnect delay between two portion boundaries} = t_2 - t_1,$$

where:

t_1 is the time of occurrence of the starting reference event;

t_2 is the time of occurrence of the ending reference event.

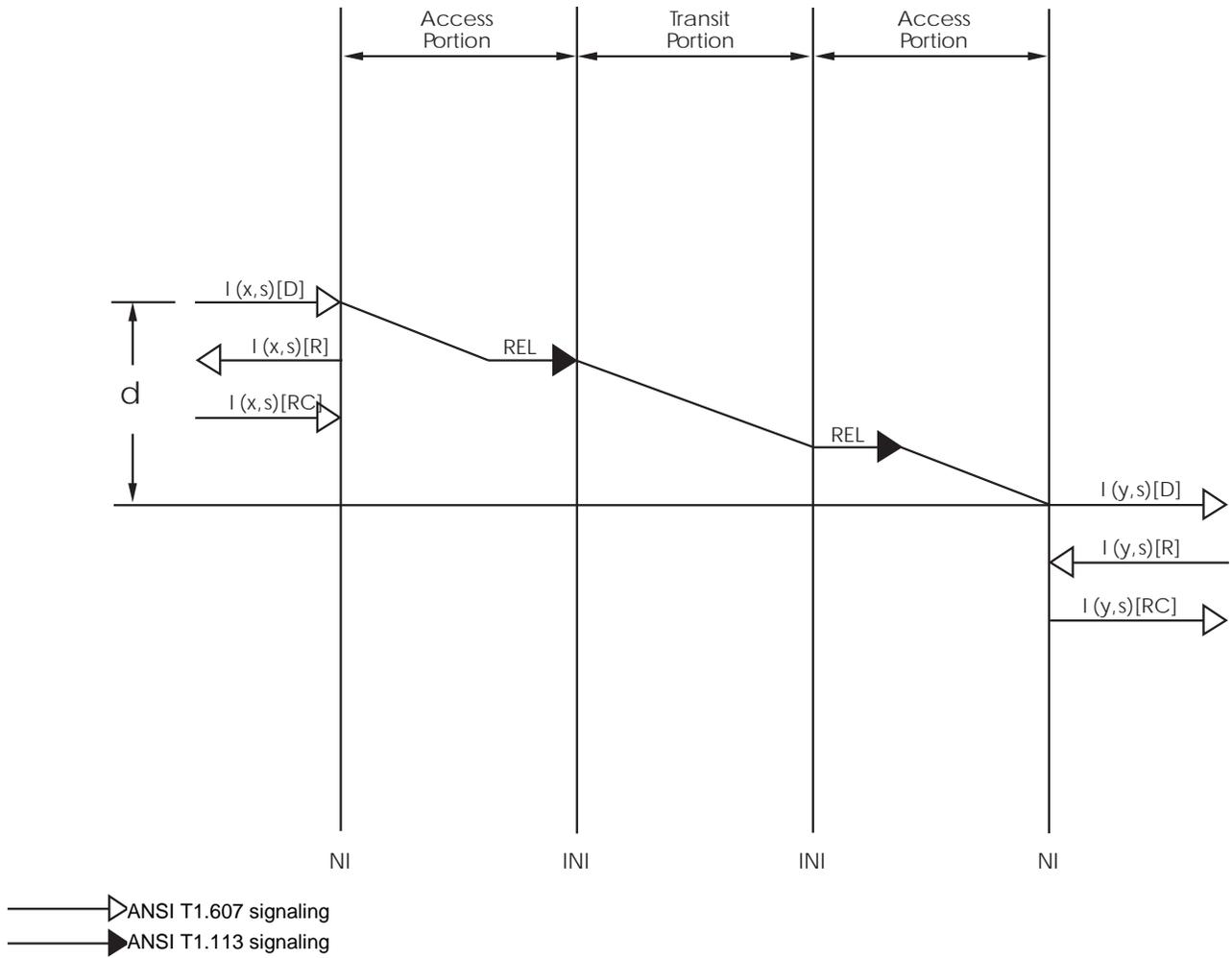


Figure 9 - Circuit mode: Disconnect delay
Figure 8 – Circuit mode: Disconnect delay

The end-to-end disconnect delay (shown as *d* in figure 8) is the disconnect delay between the two NI/T boundaries. The disconnect delay for a portion is the disconnect delay between the two boundaries delimiting that portion. The specific reference events used in measuring disconnect delay are given in tables 8a and 8b.

Table 8a – Reference events (REs) at B_i used in defining ISDN circuit mode disconnect delay

Boundary, B_i	Starting RE
Originating NI/T	P8a (DISCONNECT exit)
INI jurisdictional boundary	S4a (RELEASE exit)
Associated upstream functional boundary	S4a (RELEASE exit)
Associated downstream functional boundary	S4b (RELEASE entry)
Receiving NI/T	Not Applicable

Table 8b – Ending reference events (REs) at B_j used in defining ISDN circuit mode disconnect delay

Boundary, B_j	Ending RE
Originating NI/T	Not Applicable
INI jurisdictional boundary	S4b (RELEASE entry)
Associated upstream functional boundary	S4a (RELEASE exit)
Associated downstream functional boundary	S4b (RELEASE entry)
Receiving NI/T	P8b (DISCONNECT entry)

4.1.2.2 Disconnect delay objectives

Table 9 specifies ISDN circuit mode disconnect delay objectives for each of the portion types defined in 3.1. All values are based on (and only apply under) the following assumption:

- data link layer windows on the receiving side of the portion being specified are open.

Table 9 – Worst-case performance objectives for ISDN circuit mode disconnect delay

ISDN Connection Type	Portion type	Statistic	
		Mean (ms)	95% (ms)
64 kbit/s unrestricted switched	Access	500	FFS
	Transit	250	FFS
NOTES 1 If a satellite link is used in a connection portion, the performance objective for that portion should be increased by 300 ms. 2 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.			

4.1.3 Alerting delay

Alerting delay applies to ISDN switched connection types. This parameter is used to measure the speed of the general function of access in public ISDN switched services conforming to the standards identified in clause 2. The alerting delay parameter is applicable in the case of manual answering terminals and some automatic answering terminals.

4.1.3.1 Definition of alerting delay

Alerting delay is defined using an approach similar to that described in 4.1.1 for connection set-up delay. The overall alerting delay is shown in figure 9 (see footnote 1).

4.1.3.1.1 Definition of alerting delay observed at a single portion boundary

Alerting delay at a single portion boundary, B_j , is defined as the length of time that starts when a SETUP or the last address information message creates a reference event at B_j , and ends when the corresponding ALERTING message returns and creates its message transfer event at B_j .

$$\text{Alerting delay observed at a single portion boundary} = t_2 - t_1,$$

where:

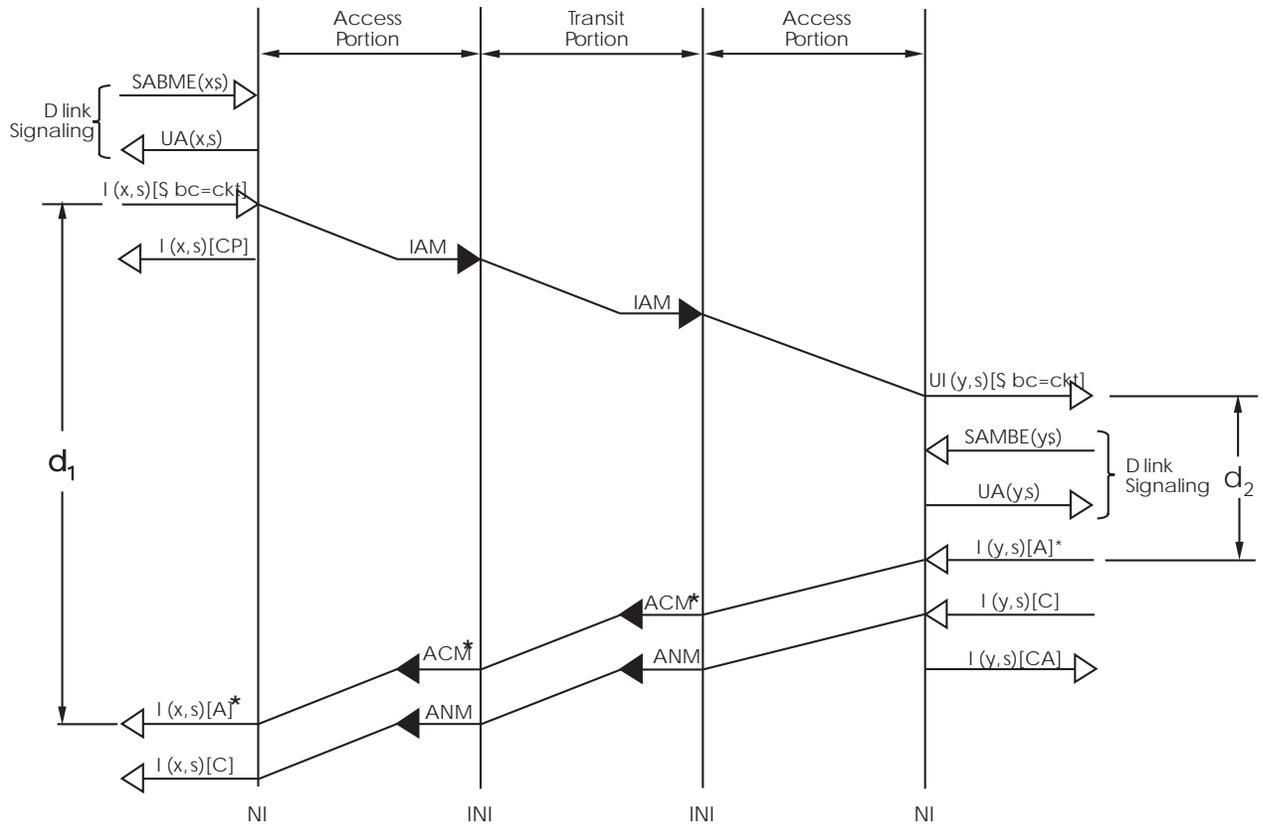
t_1 is time of occurrence of the starting reference event;

t_2 is time of occurrence of the ending reference event.

The specific reference events used in measuring alerting delay at a single boundary are shown in table 10a.

Table 10a – Reference events (REs) defining ISDN circuit mode alerting delay at a single boundary, B_j

Boundary, B_j	Starting RE	Ending RE
Originating NI/T	P1a (en bloc) (SETUP exit)	P5b (ALERTING entry)
INI jurisdictional boundary	S1a (IAM exit)	S2b (ADDRESS COMP entry)
Associated upstream functional boundary	S1a (IAM exit)	S2b (ADDRESS COMP entry)
Associated downstream functional boundary	S1b (IAM entry)	S2a (ADDRESS COMP exit)
Answering NI/T	P1b (SETUP entry)	P5a (ALERTING exit)
NOTE – En bloc and overlap sending options are defined at the calling NI/T interface.		



NOTE - * Required if voice call

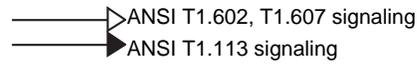


Figure 10 - Circuit mode: Overall alerting delay

Figure 9 – Circuit mode: Overall alerting delay

4.1.3.1.2 Definition of alerting delay between two portion boundaries

The alerting delay can be measured at one portion boundary, B_i , and then measured at a downstream boundary, B_j , further from the calling party. The difference in the values obtained is the alerting delay contributed by the portions between the two boundaries.

$$\text{Alerting delay between two portion boundaries} = d_i - d_j,$$

where:

d_i is the connection set-up delay measured at B_i ;

d_j is the connection set-up delay measured at B_j .

The reference events used in measuring d_i at the upstream boundary B_i are selected using table 10a. When measuring d_j , the reference events at the downstream boundary B_j are selected using table 10b.

Table 10b – Reference events (REs) defining ISDN circuit mode alerting delay at the downstream functional boundary, B_j

Boundary, B_j	Starting RE	Ending RE
Originating NI/T	Not Applicable	Not Applicable
INI jurisdictional boundary	S1b (IAM entry)	S2a (ADDRESS COMP exit)
Associated upstream functional boundary	S1a (IAM exit)	S2b (ADDRESS COMP entry)
Associated downstream functional boundary	S1b (IAM entry)	S2a (ADDRESS COMP exit)
Answering NI/T	P1b (SETUP entry)	P5a (ALERTING exit)
NOTE – En bloc and overlap sending options are defined at the calling NI/T interface.		

The end-to-end alerting delay (shown as $d_1 - d_2$ in figure 9) is the alerting delay between the two NI/T boundaries. The end-to-end alerting delay excludes the called user response time. The alerting delay for a portion is the alerting delay between the two boundaries delimiting that portion.

4.1.3.2 Alerting delay objectives

Table 11 specifies ISDN circuit mode alerting delay objectives for each of the portion types defined in 3.1. All values are based on (and only apply under) the following assumptions:

- a basic call in which the SETUP message contains no optional information elements;
- en bloc sending used;
- data link layer windows of entities outside the portion being specified are open (not flow controlled);
- no interworking with non-ISDN networks.

Table 11 – Worst-case performance objectives for ISDN circuit mode alerting delay

ISDN Connection Type	Portion type	Statistic	
		Mean (ms)	95% (ms)
64 kbit/s unrestricted switched	Access	1195	FFS
	Transit	1600	FFS
NOTES 1 If a satellite link is used in a connection portion, the performance objective for that portion should be increased by 600 ms. 2 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.			

4.2 Accuracy and dependability parameters and objectives

This subclause specifies for circuit mode ISDN bearer services accuracy and dependability parameters that can be measured or estimated at any pair of boundaries delimiting a portion or concatenation of portions.

4.2.1 Access parameters

Two circuit mode access parameters, connection set-up error probability and connection set-up failure probability, are defined in 4.2.1.

Connection set-up error and connection set-up failure are defined between pairs of portion boundaries (B_j , B_k). B_j is one of the set of boundaries to which the connection set-up attempt can properly be routed. Figure 10 identifies the sequence of four particular events that occur at these boundaries during a successful connection set-up. A connection set-up attempt over this portion is a sequential occurrence of corresponding events (a, b, c, d) prior to expiration of timer T301 (see ANSI T1.607). Connection set-up errors and connection set-up failures within this portion are defined below. Any other unsuccessful connection set-up attempt is caused by problems outside the portion and is excluded from the measurement.

4.2.1.1 Connection set-up error probability

Connection set-up error probability applies to ISDN switched connection types. This parameter is used to measure the accuracy of the general user function of access in public ISDN switched services conforming to the standards identified in clause 2.

4.2.1.1.1 Definition of connection set-up error probability

Connection set-up error probability is the ratio of total connection set-up attempts that result in connection set-up error to the total connection set-up attempts in a population of interest.

With reference to figure 10, a connection set-up error is defined to occur on any connection set-up attempt in which event (d) occurs, but event (c) does not occur at an appropriate boundary prior to expiration of timer T301.

Connection set-up error is essentially the case of a network-caused "wrong number." It occurs when the network responds to a valid connection request by erroneously establishing a connection to a destination TE other than the one designated in the connection request, and does not correct the error prior to entry to the user information transfer state. It may be caused, for example, by the administrative or maintenance actions of the network operator.

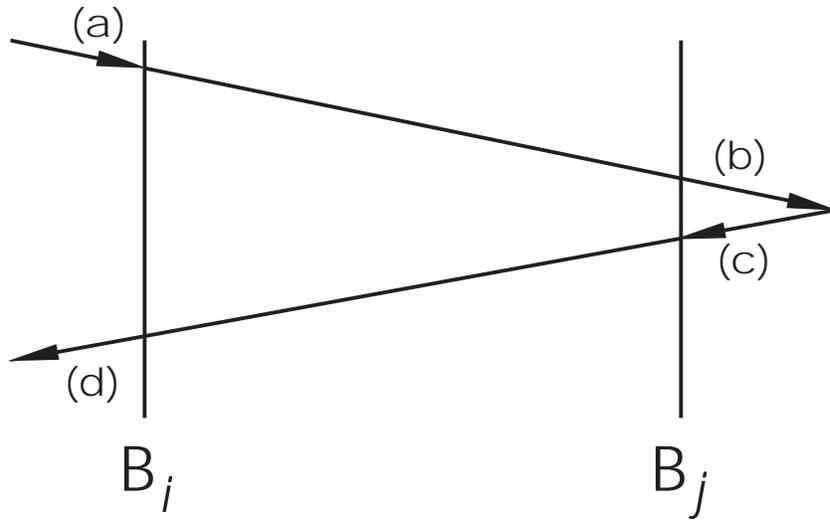


Figure 11 - Circuit mode reference events occurring during successful connection set-up

Figure 10 – Circuit mode reference events (REs) occurring during successful connection set-up

Connection set-up error is distinguished from successful connection set-up by the fact that the intended called user is not contacted and not committed to the user information transfer session during the connection set-up attempt.

The specific reference events used in measuring successful connection set-up at each portion boundary are those identified in tables 12a and 12b.

Table 12a – Reference events (REs) at B_j occurring during successful ISDN circuit mode connection set-up

Boundary, B _j	RE	
	(a)	(d)
Originating NI/T	P1a (SETUP exit)	P6b (CONNECT entry)
INI jurisdictional boundary	S1a (IAM exit)	S3b (ANSWER entry)
Associated upstream functional boundary	S1a (IAM exit)	S3b (ANS entry)
Associated downstream functional boundary	S1b (IAM entry)	S3a (ANS exit)
Receiving NI/T	Not Applicable	Not Applicable
NOTE – En bloc and overlap sending options are defined at the calling NI/T interface.		

Table 12b – Reference events (REs) at B_j occurring during successful ISDN circuit mode connection set-up

Boundary, B _j	RE	
	(b)	(c)
Originating NI/T	Not Applicable	Not Applicable
INI jurisdictional boundary	S1b (IAM entry)	S3a (ANSWER exit)
Associated upstream functional boundary	S1a (IAM exit)	S3b (IAM entry)
Associated downstream functional boundary	S1b (IAM entry)	S3a (ANS exit)
Receiving NI/T	P1b (SETUP entry)	P6a (CONNECT exit)
NOTE – En bloc and overlap sending options are defined at the calling NI/T interface.		

4.2.1.1.2 Connection set-up error probability objectives

Table 13 specifies ISDN circuit mode connection set-up error probability objectives for each of the portion types defined in 3.1. All values are based on (and only apply under) the following assumptions:

- en bloc sending used;
- no interworking with non-ISDN networks.

Table 13 – Worst-case performance objectives for ISDN circuit mode connection set-up error probability

ISDN connection type	Portion type	Statistic Probability
64 kbit/s unrestricted switched	Access	1×10^{-5}
	Transit	1×10^{-5}
NOTE – Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.		

4.2.1.2 Connection set-up failure probability

Connection set-up failure probability applies to ISDN switched connection types. This parameter is used to measure the dependability of the general function of access in public ISDN switched services conforming to the standards identified in clause 2.

4.2.1.2.1 Definition of connection set-up failure probability

Connection set-up failure probability is the ratio of total connection set-up attempts that result in connection set-up failure to the total connection set-up attempts in a population of interest.

With reference to figure 10, connection set-up failure is defined to occur on any connection set-up attempt in which either one of the following outcomes is observed prior to expiration of timer T301:

- both events (b) and (d) do not occur;
- events (b) and (c) occur, but event (d) does not.

Connection set-up attempts that are cleared by the portion as a result of incorrect performance or nonperformance on the part of an entity outside the portion are excluded.

4.2.1.2.2 Excluded connection attempts

A connection set-up attempt can also fail as a result of user blocking. Such failures are excluded from network performance measurement. Examples of user blocking include the following:

- the called user issues a message to reject the call set-up attempt;
- the CONNect message (P6b) reference event fails to occur at the originating NI/T boundary due to the lack of a CONNect message (P6a) reference event at the terminating NI/T boundary;
- the called user delays excessively in generating the CONNect message (P6a) reference event during the connection period, with the result that a connection is not established before the timeout;
- all channels at the called TE are in use.

4.2.1.2.3 Connection set-up failure probability objectives

Table 14 specifies ISDN circuit mode connection set-up failure probability objectives for each of the portion types defined in 3.1. All values are based on (and only apply under) the following assumptions:

- basic call in which the SETUP message contains no optional information elements;
- en bloc sending used;
- data link layer windows of entities outside the portion being specified are open (not flow controlled);
- no interworking with non-ISDN networks.

Table 14 – Worst-case performance objectives for ISDN circuit mode connection set-up failure probability

ISDN connection type	Portion type	Statistic
		Probability
64 kbit/s unrestricted switched	Access	FFS
	Transit	FFS
<p>NOTES</p> <p>1 ISDN circuit mode connection set-up failure probability is expected to be similar to public switched telephone network (PSTN) blocking performance. The current guidance on PSTN blocking performance is found in Committee T1 Report No. 11.</p> <p>2 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.</p>		

4.2.2 User information transfer parameters

This subclause defines four user information transfer parameters: errored second ratio, severely errored second ratio, premature disconnect event probability, and premature disconnect stimulus probability. These parameters describe impairments observed during the data transfer state of a 64 kbit/s ISDN circuit mode connection.

4.2.2.1 Errored second ratio

This parameter is used to measure the accuracy of the general function of user information transfer in public ISDN circuit mode services conforming to the standards identified in clause 2.

4.2.2.1.1 Definition of errored second ratio

An errored second is a one-second interval during which one or more errored bits are observed on a given connection between specified portion boundaries (B_p , B_p). The term, *errored bit*, is defined in 3.3.5.2. The errored second ratio for a portion is the ratio of errored seconds to total seconds in a specified time period.

This parameter measures the bit error performance of network transmission and switching equipment providing the unidirectional transfer of user information using an ISDN circuit mode connection type.

The specific reference events used in measuring errored second ratio at each portion boundary are defined in 3.3.5.1.

4.2.2.1.2 Errored second ratio objectives

Table 15 specifies ISDN circuit mode errored second ratio objectives for each of the portion types defined in 3.1. All values are based on (and only apply under) the following assumptions:

- the access link is provided by an ISDN basic rate interface;²⁾
- no interworking with non-ISDN networks.

Table 15 – Worst-case performance objectives for ISDN circuit mode errored second ratio

ISDN connection type	Portion type	Statistic
		Percent
64 kbit/s unrestricted switched	Access	0.150
	Transit	0.100

NOTES

1 If a satellite link is used in a connection portion, the performance objective for that portion shall be 1.2 percent.

2 The worst-case performance objective for ISDN circuit mode errored second ratio for an end-to-end connection consisting of two access and one transit portion types is calculated from the formula:
 $\%ES_{END-TO-END} = (2/3) * [2 * (\%ES_{ACCESS}) + \%ES_{TRANSIT}]$. For the values specified in table 15, $\%ES_{END-TO-END} = (2/3) * [2 * (0.150) + (0.100)] = 0.267$.

4.2.2.2 Severely errored second ratio

This parameter is used to measure the accuracy of user information transfer in public ISDN switched services conforming to the standards identified in clause 2.

4.2.2.2.1 Definition of severely errored second ratio

A severely errored second is a one second interval during which a bit error ratio equal to or worse than 10^{-3} is observed on a given connection between specified portion boundaries (B_i, B_j). Bit error ratio, as used here, is the ratio of the number of errored bits to the total number of transferred bits in a given one-second time interval. The term, *errored bit*, is defined in 3.3.5.2. The severely errored second ratio for a portion is the ratio of severely errored seconds to total seconds in a specified time period.

This parameter measures the bit error performance of network transmission and switching equipment providing the unidirectional transfer of user information using an ISDN circuit mode connection type.

The specific reference events used in measuring errored second ratio at each portion boundary are those defined in 3.3.5.1.

4.2.2.2.2 Severely errored second ratio objectives

²⁾ In the case in which 64-kbit/s unrestricted switched service is provided by primary rate access, the expected errored second performance of the access portion should be no worse than 0.100 percent.

Table 16 specifies ISDN circuit mode severely errored second ratio objectives for each of the portion types defined in 3.1. All values are based on (and only apply under) the following assumption:

- no interworking with non-ISDN networks.

Table 16 – Worst-case performance objectives for ISDN circuit mode severely errored second ratio

ISDN connection type	Portion type	Statistic
		Percent
64 kbit/s unrestricted switched	Access	0.010
	Transit	0.025
NOTES 1 If a satellite link is used in a connection portion, the performance objective for that portion shall be 0.03 percent. 2 The worst-case performance objective for ISDN circuit mode severely errored second ratio for an end-to-end connection consisting of two access and one transit portion types is for further study.		

4.2.2.3 Premature disconnect parameters

Premature disconnect parameters are used to quantify the probability that a connection portion (or collection of connection portions) will initiate a clearing of the connection without either end-point requesting that release. A premature disconnect event is defined to have occurred when the portion explicitly requests a clearing. A premature disconnect stimulus is defined to have occurred when the current performance of the connection portion is so bad as to be unusable, in effect provoking downstream elements to clear the connection.

The definitions in 4.2.2.3 are applicable to switched circuit mode connections.

Consider an established circuit mode connection. Let B_i and B_j represent two portion boundaries delimiting a portion or set of portions of that connection. Let L_i be the access or transit link at boundary B_i and let L_j be the access or transit link at boundary B_j . Then tables 17, 18, and 19 are tables of events that are used in determining whether the set of portions has created a premature disconnect (PD) or premature disconnect stimulus (PDS) on this connection. If an event from table 17 occurs first, the set of portions is not considered to have created a PD or a PDS. These events in table 17 are referred to as "inbound disconnect stimuli" and are not the responsibility of the portion(s) under consideration. If an event from table 18 occurs first, without a preceding event from table 17 or table 19, the set of portions has created a PD. If an event from table 19 occurs first, the set of portions has created a PDS.

Table 17 – Inbound disconnect stimuli that terminate a connection and terminate performance measurements on the connection portion(s)

Boundary, B_i or B_j	Event received by the connection portion(s)
NI/T	P8a (DISCONNECT exit)
Access link L_i or L_j	Link failure outside the portion(s)
INI jurisdictional boundary	S4a (RELEASE exit) or S6a (CIRCUIT RESET exit) or S7a (RESET exit)
Associated upstream (with respect to the packet) functional boundary	S4a (RELEASE exit) or S6a (CIRCUIT RESET exit) or S7a (RESET exit)
Associated downstream (with respect to the packet) functional boundary	S4b (RELEASE entry) or S6b (CIRCUIT RESET entry) or S7b (RESET entry)
Transit link L_i or L_j	Link failure outside the portion(s)

Table 18 – Outbound reference events (REs) defining ISDN circuit mode premature disconnect event probability

Boundary, B_i or B_j	RE transmitted by the connection portion(s)
NI/T	P8a (DISCONNECT exit)
INI jurisdictional boundary	S4b (RELEASE entry) or S6b (CIRCUIT RESET entry) or S7b (RESET entry)
Associated upstream (with respect to the packet) functional boundary	S4a (RELEASE exit) or S6a (CIRCUIT RESET exit) or S7a (RESET exit)
Associated downstream (with respect to the packet) functional boundary	S4b (RELEASE entry) or S6b (CIRCUIT RESET entry) or S7b (RESET entry)

Table 19 – Outbound events defining ISDN circuit mode premature disconnect stimulus probability

Boundary, B_i or B_j	Event transmitted by the connection portion(s)
NI/T	10 consecutive SES from B_i to B_j or 10 consecutive SES from B_j to B_i
Access link L_i or L_j	Link failure inside the portion(s)
INI jurisdictional boundary or associated functional boundary	10 consecutive SES from B_i to B_j or 10 consecutive SES from B_j to B_i
Transit link L_i or L_j	Link failure inside the portion(s)

NOTE – Although all events in table 18 are instantaneous, events in tables 17 and 19 may require as many as 10 seconds to complete. An event from table 17 or table 19 will be considered to have preceded an event from table 18 if the table 17 or table 19 event has completed before the table 18 event occurs. An event from table 17 will be considered to have preceded an event from table 19 if the table 17 event has begun before the table 19 event begins.

4.2.2.3.1 Definition of inbound disconnect stimulus

If any of the events listed in table 17 are received by the set of connection portions, this event is considered terminated. At that time, no aspects of the performance of the set of connection portions can be judged further. In particular, following an event from table 17, the portion(s) may begin to release the connection and neither a premature disconnect nor a premature disconnect stimulus can be attributed to this set of portions.

The entry "Link failure outside the portion(s)" refers to a physical layer failure of L_i or L_j outside the boundaries of the portion(s) under consideration. If either L_i or L_j fails due to causes outside the portions under test, this failure is considered an inbound disconnect stimuli. The exact definition of the link failure varies among networks, but always includes consecutive SES events (from 2.5 to 10 seconds) measured at the full bit rate of the link (see ANSI T1.503).

4.2.2.3.2 Premature disconnect event probability

A premature disconnect event (PD) is defined to have been generated within a set of portions when, in the absence of any preceding inbound disconnect stimulus (see table 17), any of the events specified in table 18 are transmitted out of the portion(s).

Following the premature disconnect event, no aspects of the performance of the set of connection portions can be judged further. In particular, following an event from table 18, no further premature disconnect events and no premature disconnect stimuli can be attributed to this set of portions. In response to a premature disconnect event, the users of the connection should complete the clearing process and establish a new connection as needed.

4.2.2.3.2.1 Definition of premature disconnect event probability

The premature disconnect event probability for a portion or set of portions is the probability, in any given second, that a connection experiences a premature disconnection event generated within those portions.

4.2.2.3.2.2 Premature disconnect event probability objectives

Table 20 specifies ISDN circuit mode premature disconnect event probability objectives for each of the portion types defined in 3.1.

Table 20 – Worst-case performance objectives for ISDN circuit mode premature disconnect event probability

ISDN connection type	Portion type	Statistic
		Probability per virtual connection second
64 kbit/s unrestricted switched	Access	5×10^{-6}
	Transit	5×10^{-6}
NOTE – Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.		

4.2.2.3.3 Premature disconnect stimulus probability

A premature disconnect stimulus (PDS) is defined to have been generated within a set of portions when, in the absence of any preceding inbound disconnect stimulus (see table 17), any of the events specified in table 19 are transmitted out of the portion(s).

The entry "Link failure inside the portion(s)" refers to a physical layer failure of L_i or L_j inside the boundaries of the portion(s) under consideration. If either L_i or L_j fails due to causes inside the portions under test, this failure is considered a premature disconnect stimuli. The exact definition of the link failure varies among networks, but always includes consecutive SES events (from 2.5 to 10 seconds) measured at the full bit rate of the link (see ANSI T1.503). At the NI/T boundary, a link failure is defined to be equivalent to 10 consecutive SES as measured at the full bit rate of the access link (see ANSI T1.503).

The entries "10 consecutive SES from B_i to B_j" and "10 consecutive SES from B_j to B_i" refer to SES measured on the switched connection at the 64 kbit/s rate (see 4.2.2.2).

Following the premature disconnect stimulus no aspects of the performance of the set of connection portions can be judged further. In particular, following an event from table 19, no further premature disconnect stimuli and no premature disconnect events can be attributed to this set of portions. Also, any SES on a connection that are ultimately involved in triggering a PDS are not considered in the evaluation of ISDN SES performance. In response to a premature disconnect stimulus, it is recommended that the users of the connection clear the connection and establish a new connection as needed.

4.2.2.3.3.1 Definition of premature disconnect stimulus probability

The premature disconnect stimulus probability for a portion or set of portions is the probability, in any given second, that a connection experiences (the final second of) a premature disconnection stimulus generated within those portions.

4.2.2.3.3.2 Premature disconnect stimulus probability objectives

Table 21 specifies ISDN circuit mode premature disconnect stimulus probability objectives for each of the portion types defined in 3.1.

Table 21 – Worst-case performance objectives for ISDN circuit mode premature disconnect stimulus probability

ISDN connection type	Portion type	Statistic
		Probability per virtual connection second
64 kbit/s unrestricted switched	Access	1×10^{-6}
	Transit	1×10^{-6}
NOTE – Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.		

4.2.3 Disengagement performance – Connection clearing failure probability

Connection clearing failure probability applies to ISDN switched connection types. This parameter is used to measure the accuracy and dependability of disengagement in ISDN circuit mode services conforming to the standards identified in clause 2.

4.2.3.1 Definition of connection clearing failure probability

Connection clearing failure probability is the ratio of total connection clearing failures to the total connection clearing attempts in a population of interest.

Connection clearing failure is defined with reference to events at the boundaries of a portion (B_i, B_j). A connection clearing attempt occurs when a DISConnect or RElease message enters the portion creating a reference event at B_i. A connection clearing failure occurs when no corresponding connection clearing reference event occurs at B_j within X seconds.

NOTE – The value of X is for further study. The relevant reference events used in measuring disconnection set-up failure probability at each portion boundary are those identified in tables 22a and 22b.

Table 22a – Starting Reference events (REs) at B_i used in defining ISDN circuit mode connection set-up failure probability

Boundary, B _i	Starting RE
--------------------------	-------------

Originating NI/T	P8a (DISCONNECT exit)
INI jurisdictional boundary	S4a (RELEASE exit)
Associated upstream functional boundary	S4a (RELEASE exit)
Associated downstream functional boundary	S4b (RELEASE entry)
Receiving NI/T	Not Applicable

Table 22b – Reference events (REs) at B_j whose nonoccurrence is used in defining ISDN circuit mode set-up connection set-up failure probability

Boundary, B _j	RE
Originating NI/T	Not Applicable
INI jurisdictional boundary	S4b (RELEASE entry)
Associated upstream functional boundary	S4a (RELEASE exit)
Associated downstream functional boundary	S4b (RELEASE entry)
Receiving NI/T	P8b (DISCONNECT entry)

4.2.3.2 Connection clearing failure probability objectives

Table 23 specifies ISDN circuit mode connection clearing failure objectives for each of the portion types defined in 3.1. All values are based on (and only apply under) the following assumptions:

- data link layer windows of entities outside the portion being specified are open (not flow controlled);
- no interworking with non-ISDN networks.

Table 23 – Worst-case performance objectives for ISDN circuit mode connection clearing failure probability

ISDN connection type	Portion type	Statistic
		Probability
64 kbit/s unrestricted switched	Access	FFS
	Transit	FFS

4.3 Availability parameters and objectives

This subclause specifies for circuit mode ISDN bearer services availability parameters that can be measured or estimated at any pair of boundaries delimiting a portion or concatenation of portions. Two availability parameters, service availability and mean time between service outages are defined.

A two-state model provides a basis for describing overall service availability. A specified availability function compares the values for a set of "supported" primary parameters with corresponding outage threshold to classify the service as "available" (no service outage) or "unavailable" (service outage) during scheduled service time. This subclause defines the availability function and the associated availability parameters that characterize the resulting binary random process, and specifies the availability performance objectives.

4.3.1 Availability function

Four performance parameters are used in computing the availability of a circuit mode connection portion: connection set-up error probability, connection set-up failure probability, premature disconnect stimulus probability, and premature disconnect event probability. Two particular linear combinations of these parameters are called the availability decision parameters. Each decision parameter is associated with an outage threshold. These decision parameters and their outage thresholds are listed in table 24.

Table 24 – Outage criteria for the ISDN circuit mode availability decision parameters

ISDN connection type	Availability decision parameters	Criteria
64 kbit/s unrestricted switched	Connection set-up error probability (CEP), Connection set-up failure probability (CFP)	CEP + CFP > 0.9
	Premature disconnect stimulus probability (PDSP), Premature disconnect event probability (PDEP)	PDSP + PDEP > 0.001
NOTE – The connection portion (or set of connection portions) may also be considered unavailable if the underlying physical layer at either portion boundary is unavailable (no signal, alarm condition, etc.) due to causes within the connection portion(s).		

Performance is considered independently with respect to each availability decision parameter. If the value of the parameter is equal to or better than the defined outage threshold, performance relative to that parameter is defined to be acceptable. If the value of the parameter is worse than the threshold, performance relative to that parameter is defined to be unacceptable.

A connection portion is defined to be *available* (or to be in the available state) if the performance is acceptable relative to all decision parameters.

The connection portion is defined to be *unavailable* (or to be in the unavailable state) if the performance of one or more of the four decision criteria is unacceptable.

The intervals during which a connection portion is unavailable are identified by superimposing the unacceptable performance periods for all decision parameters as illustrated in figure 11.

In order to exclude transient impairments from being considered as periods of unavailability, a single test of the availability state must be at least 5 minutes. In order to reduce the probability of state transitions during a test of the current availability state, that test should be less than 20 minutes.

4.3.2 Service availability

Two availability parameters are defined: service availability (SA) and mean time between service outages (MTBSO).

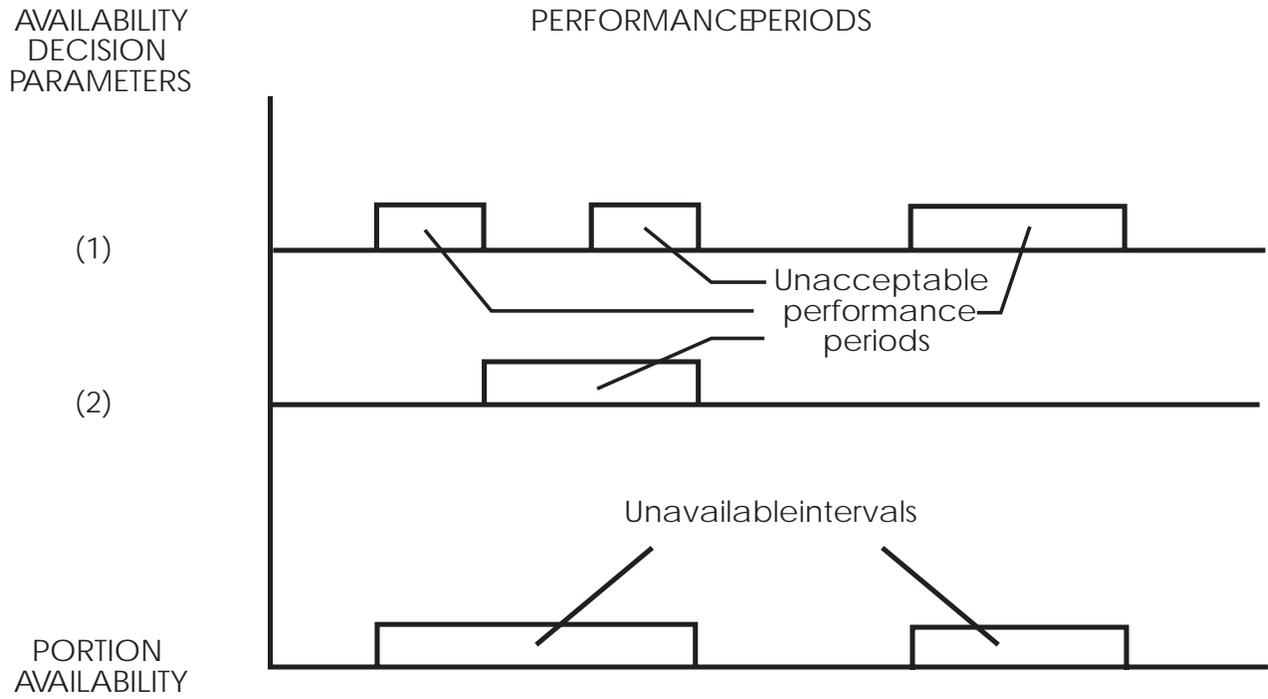


Figure 12 - Determination of ISDN circuit mode availability states

Figure 11 – Determination of ISDN circuit-mode availability states

4.3.2.1 Definition of service availability

The service availability for a connection portion is the long-term percentage of scheduled service time in which that portion is available.

Scheduled service time for a portion is the time during which the network provider has agreed to make that portion available for service. Typically, the scheduled service time is 24 hours per day, 7 days a week.³⁾

4.3.2.2 Service availability objectives

Table 25 specifies ISDN circuit mode service availability objectives for each of the portion types defined in 3.1. All values are based on (and only apply under) the same assumptions used in specifying the primary parameters.

Table 25 – Worst-case performance objectives for ISDN circuit mode service availability

ISDN connection type	Portion type	Statistic
		Percent
64 kbit/s unrestricted switched	Access	FFS
	Transit	FFS

4.3.3 Mean time between service outages

4.3.3.1 Definition of mean time between service outages

The mean time between service outages for a connection portion is the average duration of any continuous interval during which the portion is available. Consecutive intervals of scheduled service time are concatenated.

4.3.3.2 Mean time between service outage objectives

Table 26 specifies ISDN circuit mode mean time between service outage objectives for each of the portion types defined in 3.1. All values are based on (and only apply under) the same assumptions used in specifying the primary parameters:

Table 26 – Worst-case performance objectives for ISDN circuit mode mean time between service outages

ISDN connection type	Portion type	Statistic
		Hours
64 kbit/s unrestricted switched	Access	FFS
	Transit	FFS

4.3.4 Related parameters

Four other parameters are commonly used in describing availability performance. These are generally defined as follows:

- Mean time to service restoral (MTTSR) is the average duration of unavailable service time intervals;

³⁾ Other scheduled service times may be specified in some networks.

- Failure rate (λ) is the average number of transitions from the available state to the unavailable state per unit available time;
- Restoral rate (μ) is the average number of transitions from the unavailable state to the available state per unit unavailable time;
- Unavailability (U) is the long-term ratio of unavailable service time to scheduled service time, expressed as a percentage.

Under the exponential distribution assumption of failure and restoration, the mathematical values for any of these parameters may be estimated from the values for service availability (SA) and mean time between service outages (MTBSO) as summarized in figure 12.

5 Packet mode ISDN bearer services

This clause defines performance parameters and specifies associated worst-case performance objectives for packet mode ISDN bearer services. Availability decision parameters and associated worst-case performance objectives for packet mode ISDN bearer services are defined in clause 5. Performance-related definitions for ISDN terminal equipment are not specified; however, the parameters defined in this clause may be employed in such definitions to assist users in establishing relationships between network performance and quality of service.

5.1 Speed of service parameters and objectives

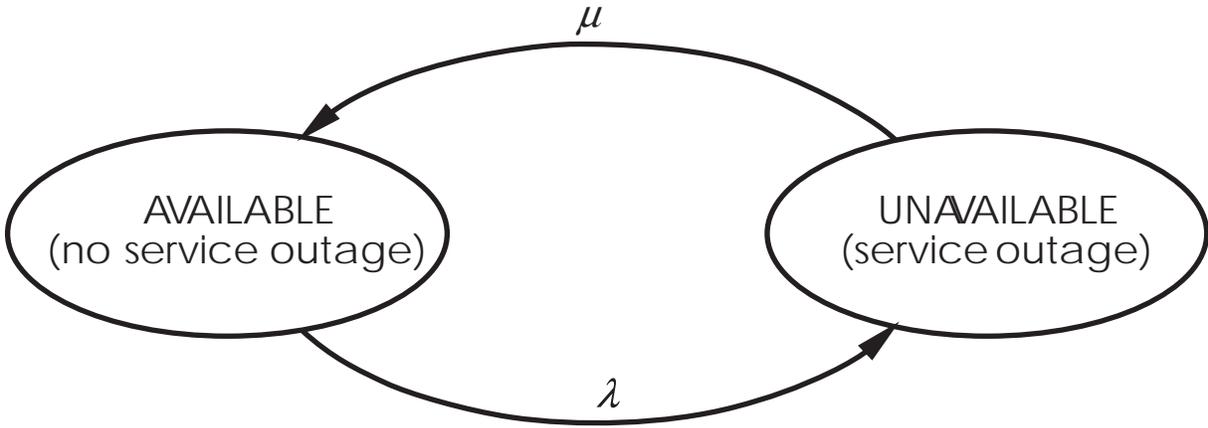
This subclause specifies for packet mode ISDN bearer services delay parameters that can be measured or estimated between any pair of boundaries delimiting a portion or concatenation of portions.

5.1.1 Call set-up delay

5.1.1.1 Definition of call set-up delay

Call set-up delay is defined below in terms of sequences of events that either cross an INI boundary, or directly trigger or are caused by such an event. Call set-up delay applies only to the ISDN X.25 virtual circuit packet mode bearer service.

Call set-up delay observed at a single portion boundary is defined first and then call set-up delay between a pair of portion boundaries is defined based on the former definition. Two cases of call set-up delay are defined based on the state of the called TE.



(a) State diagram

$$MTBSO = \frac{1}{\lambda}$$

$$MTTSR = \frac{1}{\mu}$$

$$SA = 100 \left[\frac{MTBSO}{MTBSO + MTTSR} \right] = 100 \left[\frac{\mu}{\lambda + \mu} \right]$$

$$U = 100 - SA = 100 \left[\frac{MTTSR}{MTBSO + MTTSR} \right] = 100 \left[\frac{\lambda}{\lambda + \mu} \right]$$

(b) Parameter relationships

Figure 13 - Basic availability model and parameters

Figure 12 - Basic availability model and parameters

5.1.1.1.1 Call set-up delay: Case 1

Case 1 occurs when there is no established B or D channel to the packet handler (PH) of the called party, as shown in figure 13.⁴⁾ The events of the calling party from the initial SABME(x,s) to the UA(B)/(x,p) are for illustration only, and indicate the maximal number of events needed to connect a channel to the PH of the local switch, and place a link layer over that same channel in the correct state for an X.25 call request packet to be sent.

In terms of Case B identified in ITU-T Recommendation X.31, case 1 applies when the B or D channel of the called party has conditional or unconditional notification. For Case A identified in X.31, case 1 applies to a called party having a demand connection to the public packet switching node access unit (AU).

The time between the exit event of the X.25 call request packet at the originating NI/T boundary and the time that the corresponding ANSI T1.607 set-up message entrance event occurs at the called NI/T boundary counts towards the end-to-end call set-up delay. The time between the exit event of the X.25 call accept packet at the called NI/T boundary and the entrance event of the corresponding X.25 call connect packet at the calling NI/T boundary is also counted towards the call set-up delay. These are the only two components of end-to-end call set-up delay in this case.

The events that occur between the arrival of the ANSI T1.607 set-up message at the called NI/T boundary and the exit of the X.25 call-accepted (CA) packet at the called NI/T boundary indicate the maximal number of events needed for a channel to be established to the PH, placed in the appropriate state, and have an X.25 CA packet issued.

5.1.1.1.1.1 Definition of call set-up delay at a single portion boundary for case 1: Call set-up delay at a portion boundary (B_i) is defined as the period of time that starts when either an X.25 call-request packet or an ANSI T1.607 set-up message creates an event at B_i and ends with the corresponding X.25 call-connected or call-accepted packet, accepting the virtual call, returns and creates an event at B_i .

$$\text{Call set-up delay observed at a single portion boundary} = t_2 - t_1,$$

where:

t_1 is the time of the starting reference event;

t_2 is the time of the ending reference event.

5.1.1.1.1.2 Definition of call set-up delay between two portion boundaries for case 1: Call set-up delay between two portion boundaries, B_i and B_j (with B_j being farther than B_i from the calling TE), is defined as the difference $d_i - d_j$ of the call set-up delays at B_i and B_j , respectively.

$$\text{Call set-up delay between two portion boundaries} = d_i - d_j,$$

where:

d_i is the call set-up delay measured at B_i ;

d_j is the call set-up delay measured at B_j .

⁴⁾ Starting in figure 13, the notation used in the two pairs of events, {SABME(B)/(x,s), A(B)/(x,s)} and {SABME(B)/(x,s), UA(B)/(x,s)} denotes the possible use of either a B or D channel to provide packet mode bearer service. The slash separates a B channel LAPB address, (A) or (B), from a D channel LAPD address, (x,s) or (y,s). The type of address used must be the same within a pair of events. Thus, for example, at the initial NI, either {SABME(B), UA(B)} or {SABME(x,s), UA(x,s)} are valid combinations, but not {SABME(B), UA(x,s)} nor {SABME(x,s), UA(B)}.

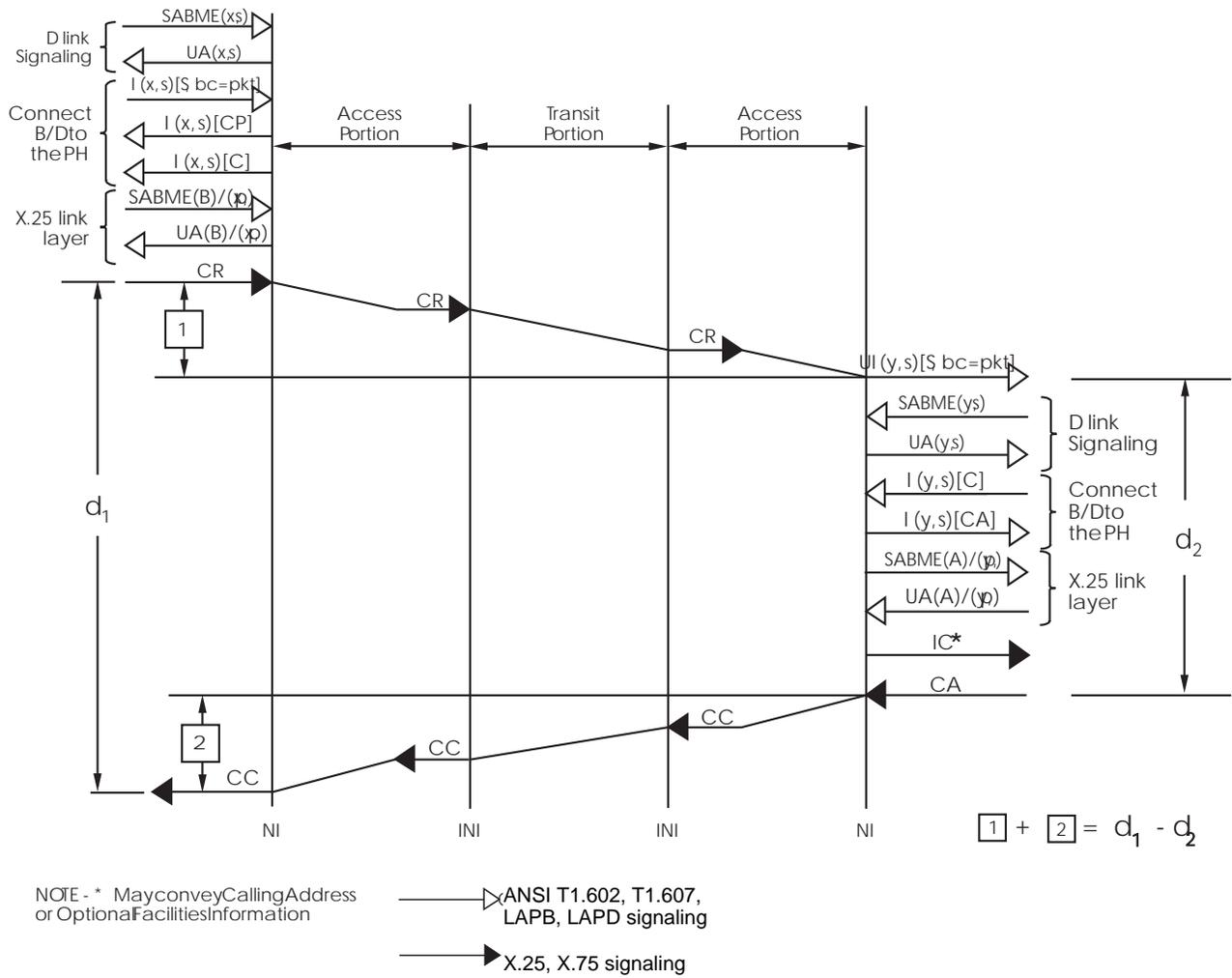


Figure 14 - Packet mode (case 1): End-to-end call set-up delay

Figure 13 – Packet mode (case 1): End-to-end call set-up delay

5.1.1.1.1.3 Definition of end-to-end call set-up delay for case 1: End-to-end call set-up delay is defined (see figure 13) as the difference $d_1 - d_2$ where d_1 is the time between the exit event of the call-request packet and the entry event of the call-connected packet at the calling NI/T boundary and d_2 is the time between the entry event of the ANSI T1.607 set-up message and the exit event of the X.25 call-accepted packet at the called NI/T boundary.

5.1.1.1.1.4 Definition of access portion call set-up delay for case 1: The access portion call set-up delay is the call set-up delay between the two portion boundaries of the access portion.

5.1.1.1.1.5 Definition of transit portion call set-up delay for case 1: The transit portion call set-up delay is the call set-up delay between the two portion boundaries of the transit portion.

The specific reference events that are used to define ISDN packet mode call set-up delay for case 1 at each portion boundary are identified in tables 27a and 27b. The reference events used in measuring d_i at the upstream boundary B_i are selected using table 27a. When measuring d_j , the reference events at the downstream boundary B_j are selected using table 27b.

Table 27a – Reference events (REs) used in defining ISDN packet mode connection set-up delay (case 1) at a single boundary, B_i

Boundary, B_i	Starting RE	Ending RE
Originating NI/T	2 (X.25 Call Request exit)	3 (X.25 Call Connected entry)
INI jurisdictional boundary	1 (X.75 Call Request exit)	2 (X.75 Call Connected entry)
Associated upstream functional boundary	1 (X.75 Call Request exit)	2 (X.75 Call Connected entry)
Associated downstream functional boundary	1 (X.75 Call Request entry)	2 (X.75 Call Connected exit)
Answering NI/T	P1b (SETUP entry)	4 (X.25 Call Accepted exit)

Table 27b – Reference events (REs) used in defining ISDN packet mode connection set-up delay (case 1) at a downstream boundary, B_j

Boundary, B_j	Starting RE	Ending RE
Originating NI/T	Not Applicable	Not Applicable
INI jurisdictional boundary	1 (X.75 Call Request entry)	2 (X.75 Call Connected exit)
Associated upstream functional boundary	1 (X.75 Call Request exit)	2 (X.75 Call Connected entry)
Associated downstream functional boundary	1 (X.75 Call Request entry)	2 (X.75 Call Connected exit)
Answering NI/T	P1b (SETUP entry)	4 (X.25 Call Accepted exit)

5.1.1.1.2 Call set-up delay: Case 2

End-to-end call set-up delay for case 2, shown in figure 14 (see footnote 4), coincides with that specified in 4.1.2 of ANSI T1.504. This is because the events prior to the exit event of the X.25 call-request packet are not part of the definition of call set-up delay in either case, and there is already a B or D channel connected to the PH and in the appropriate layer 2 state at the called NI/T boundary to accept an X.25 incoming call packet.

In terms of Case B defined in X.31, case 2 applies when the B or D channel of the called party is semi-permanent or has no notification. For Case A defined in X.31, case 2 applies to a called party having a semi-permanent connection to the public packet-switched node access unit (AU).

5.1.1.1.2.1 Definition of call set-up delay at a single portion boundary for case 2: Call set-up delay at a portion boundary (B_i) is defined as the period of time that starts when either an X.25 call-request packet or an incoming call packet creates an event at B_i and ends with the corresponding X.25 call-connected or call-accepted packet, accepting the virtual call, returns and creates an event at B_i .

$$\text{Call set-up delay observed at a single portion boundary} = t_2 - t_1,$$

where:

t_1 is the time of the starting reference event;

t_2 is the time of the ending reference event.

5.1.1.1.2.2 Definition of call set-up delay between two portion boundaries for case 2: Call set-up delay between two portion boundaries, B_i and B_j (with B_j being farther than B_i from the calling TE), is defined as the difference $d_i - d_j$ of the call set-up delays at B_i and B_j respectively.

$$\text{Call set-up delay between two portion boundaries} = d_i - d_j,$$

where:

d_i is the call set-up delay measured at B_i ;

d_j is the call set-up delay measured at B_j .

5.1.1.1.2.3 Definition of end-to-end call set-up delay for case 2: End-to-end call set-up delay is defined (see figure 14) as the difference $d_1 - d_2$ where d_1 is the time between the exit event of the call-request packet and the entry event of the call-connected packet at the calling NI/T boundary and d_2 is the time between the entry event of the ANSI T1.607 set-up message and the exit event of the X.25 call-accepted packet at the called NI/T boundary.

5.1.1.1.2.4 Definition of access portion call set-up delay for case 2: The access portion call set-up delay is the call set-up delay between the two portion boundaries of the access portion.

5.1.1.1.2.5 Definition of transit portion call set-up delay for case 2: The transit portion call set-up delay is the call set-up delay between the two portion boundaries of the transit portion.

The specific reference events that are used to define call set-up delay for case 2 at each portion boundary 2 are identified in tables 28a and 28b. The reference events used in measuring d_i at the upstream boundary B_i are selected using table 28a. When measuring d_j , the reference events at the downstream boundary B_j are selected using table 28b.

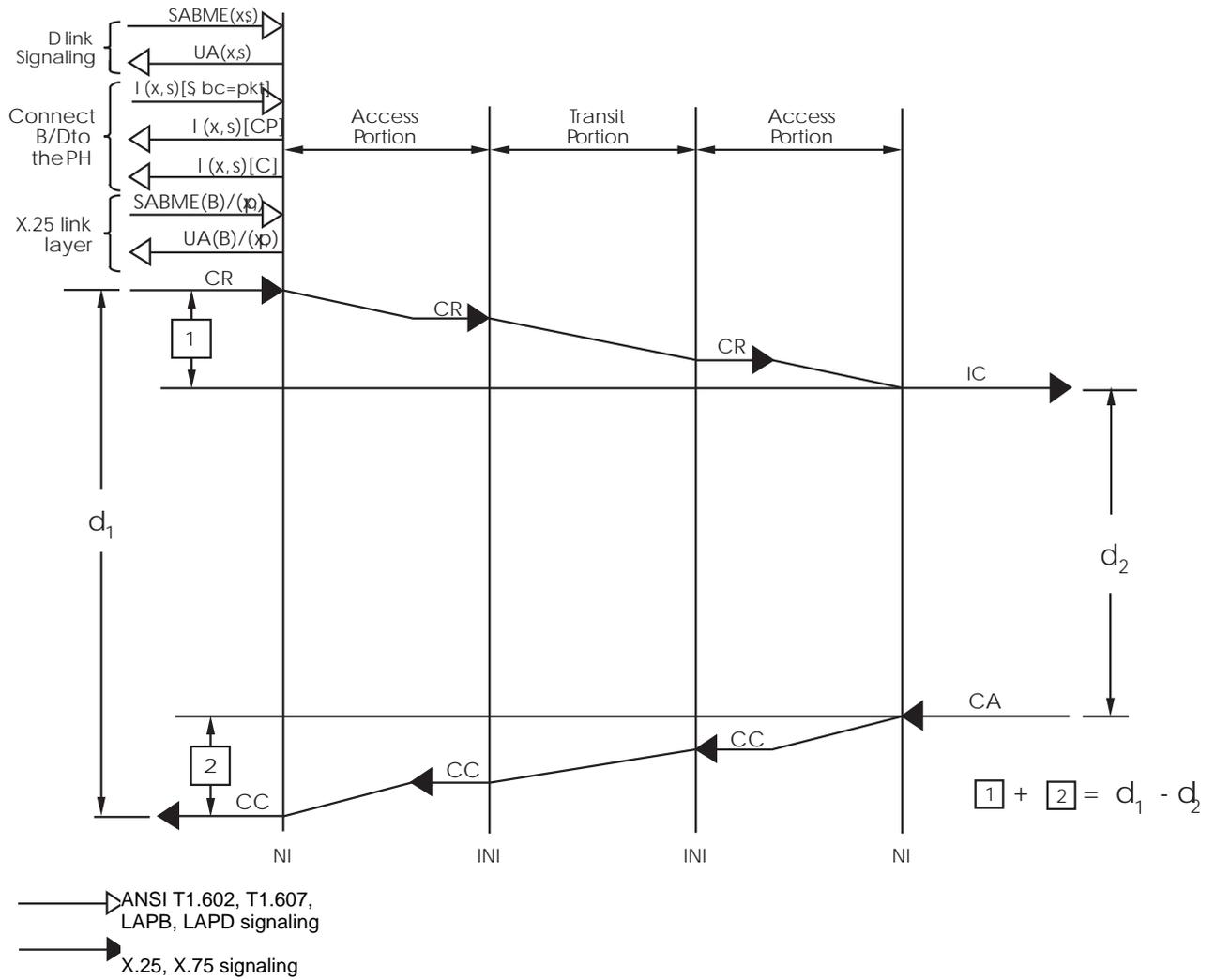


Figure 15 - Packet mode (case 2): End-to-end call set-up delay

Figure 14 – Packet mode (case 2): End-to-end call set-up delay

Table 28a – Reference events (REs) used in defining ISDN packet mode connection set-up delay (case 2) at a single boundary, B_j

Boundary, B _j	Starting RE	Ending RE
Originating NI/T	2 (X.25 Call Request exit)	3 (X.25 Call Connected entry)
INI jurisdictional boundary	1 (X.75 Call Request exit)	2 (X.75 Call Connected entry)
Associated upstream functional boundary	1 (X.75 Call Request exit)	2 (X.75 Call Connected entry)
Associated downstream functional boundary	1 (X.75 Call Request entry)	2 (X.75 Call Connected exit)
Answering NI/T	1 (X.25 Incoming Call entry)	4 (X.25 Call Accepted exit)

Table 28b – Reference events (REs) used in defining ISDN packet mode connection set-up delay (case 2) at a downstream boundary, B_j

Boundary, B _j	Starting RE	Ending RE
Originating NI/T	Not Applicable	Not Applicable
INI jurisdictional boundary	1 (X.75 Call Request entry)	2 (X.75 Call Connected exit)
Associated upstream functional boundary	1 (X.75 Call Request exit)	2 (X.75 Call Connected entry)
Associated downstream functional boundary	1 (X.75 Call Request entry)	2 (X.75 Call Connected exit)
Answering NI/T	1 (X.25 Incoming Call entry)	4 (X.25 Call Accepted exit)

5.1.1.2 Call set-up delay objectives

Table 29 specifies the objectives for ISDN packet mode call set-up delay (cases 1 and 2 defined in 5.1.1.1) for each of the portion types defined in 3.1. All values are based on (and only apply under) the following assumptions:

- a basic call in which none of the optional user facilities defined in ITU-T Recommendation X.25 are used and no called user data is sent;
- data link layer windows of entities outside the portion being specified are open (i.e., not flow controlled);
- ISDN access is used at both ends of the call.

Table 29 – Worst-case performance objectives for ISDN packet mode call set-up delay (cases 1 and 2)

ISDN connection type	Portion type	Statistic	
		Mean (ms)	95% (ms) ¹⁾
Packet mode	Access; Nominal interconnection	1050 + X	FFS
	Access; Cooperatively planned interconnection	750 + X	FFS
	Transit	600	FFS
<p>NOTES</p> <p>1 The value of X depends on the signaling rate of the channel (B or D) and is defined in table 15 of ANSI T1.504b. On the BRI D-channel, X = 25 ms. On a 64-kbit/s channel X = 6.25 ms.</p> <p>2 Intended use, applicability, and general assumptions relevant to these objectives are discussed in 8.1 of ANSI T1.504b. As a consequence of increased integration of the ISDN packet handler and the public packet-switched network, the performance objectives specified in ANSI T1.517 will be revised in the future.</p> <p>3 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.</p> <p>1) It is expected that 95 percent of the measured call set-up delays will fall within the range $[0, \mu + 2\mu]$, where μ is the mean call set-up delay.</p>			

5.1.2 Data packet transfer delay

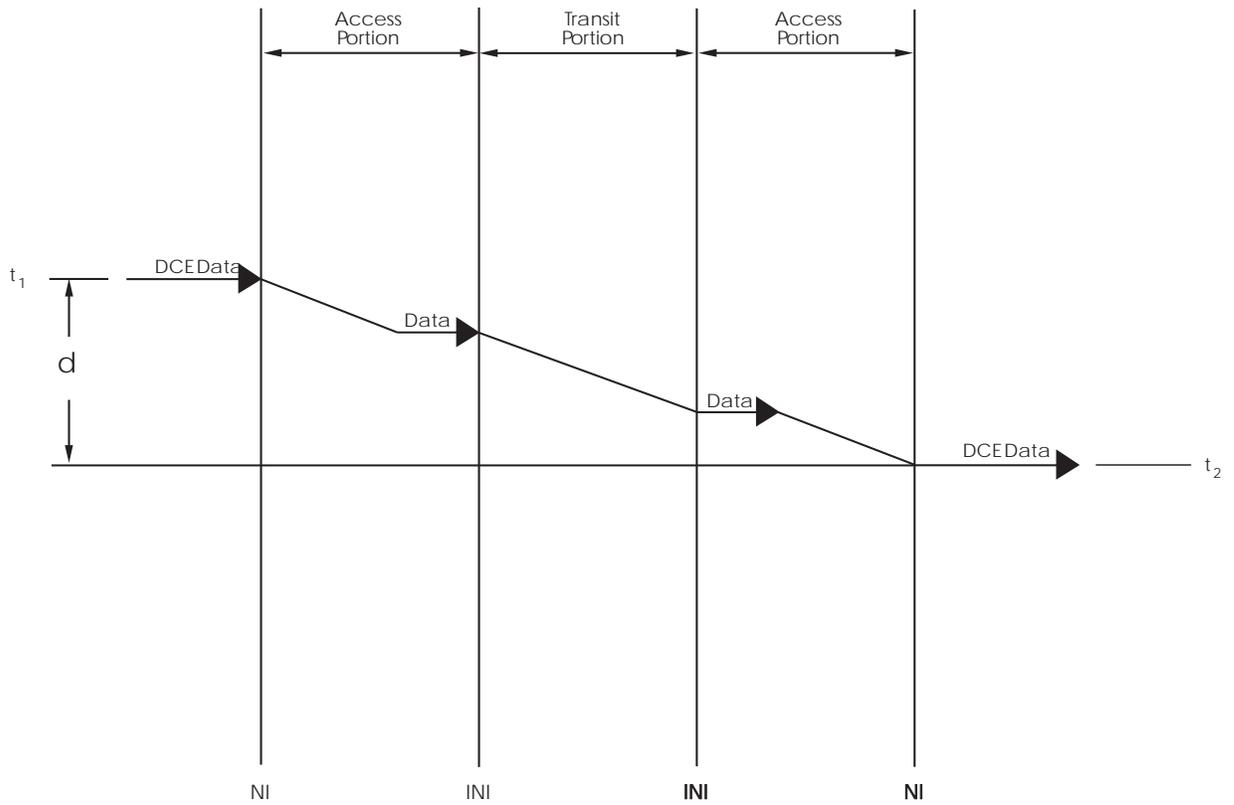
5.1.2.1 Definition of data packet transfer delay

Data packet transfer delay, as defined in 4.2 of ANSI T1.504 (see also 8.2 of ANSI T1.504b), applies to ISDN packet mode service. The end-to-end data packet transfer delay is the one-way delay between the NI/T boundaries (shown as d in figure 15). The access portion data packet transfer delay is the delay between the boundaries delimiting an access portion. The transit portion data packet transfer delay is the delay between the boundaries delimiting a transit portion.

5.1.2.2 Data packet transfer delay objectives

Table 30 specifies the objectives for ISDN packet mode data packet transfer delay for each of the portion types defined in 3.1. All values are based on (and only apply under) the following assumptions:

- a user information field length of 128 octets;
- data link and packet layer windows on the receiving side of the portion being specified are open (i.e., not flow controlled);
- ISDN access is used at both ends of the call.



→ X.25, X.75 Signaling
 X.25, X.75 signaling

Figure 16 - Packet mode: End-to-end data packet transfer delay

Table 30 – Worst-case performance objectives for ISDN packet mode data packet transfer delay

ISDN connection type	Portion type	Statistic	
		Mean (ms)	95% (ms) ¹⁾
Packet mode	Access; Nominal Interconnection	650 + Y	FFS
	Access; Cooperatively planned interconnection	250 + Y	FFS
	Transit	300	FFS
<p>NOTES</p> <p>1 The value of Y depends on the signaling rate of the channel (B or D) and is defined in table 17 of ANSI T1.504b. On the BRI D-channel, Y= 68 ms. On a 64-kbit/s channel, Y= 17 ms.</p> <p>2 Intended use, applicability, and general assumptions relevant to these objectives are discussed in 8.1 of ANSI T1.504b. As a consequence of increased integration of the ISDN packet handler and the public packet-switched network, the performance objectives specified in ANSI T1.517 will be revised in the future.</p> <p>3 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.</p> <p>¹⁾ It is expected that 95 percent of the measured data packet transfer delays will fall within the range $[0, \mu + 2\mu]$, where μ is the mean data packet transfer delay.</p>			

5.1.3 Throughput parameters

Three throughput parameters (throughput, steady-state throughput, and throughput capacity) are defined in 5.1.3.

5.1.3.1 Definition of throughput

Throughput, as defined in 4.3.1 of ANSI T1.504 (see also 8.2 of ANSI T1.504b), applies to ISDN packet mode service.

5.1.3.2 Definition of steady-state throughput

Steady-state throughput, as defined in 4.3.2 of ANSI T1.504 (see also 8.2 of ANSI T1.504b), applies to ISDN packet mode service.

5.1.3.3 Definition of throughput capacity

Steady-state throughput, as defined in 4.3.3 of ANSI T1.504 (see also 8.2 of ANSI T1.504b), applies to ISDN packet mode service.

5.1.3.4 Throughput capacity objectives

Table 31 specifies the objectives for ISDN packet mode throughput capacity for each of the portion types defined in 3.1. All values are based on (and only apply under) the following assumptions:

- B-channel user data transfer;
 - no other traffic on the relevant access link B-channel;
 - a user information field length of 128 octets and requested throughput class corresponding to 9600 bits/s;
- NOTE – The throughput class finally applying to the call may be lower than the requested throughput class.

- packet layer window sizes of 2 and data link layer window sizes of 7 on the access links;
- D bit is not used ($D = 0$);
- values apply to either direction of transfer;
- no resets or premature disconnects during the observation period;
- throughput capacity measurement period of at least 2 minutes;
- ISDN access is used at both ends of the call.

Table 31 – Worst-case performance objectives for ISDN packet mode throughput capacity

ISDN connection type	Portion type	Statistic	
		Mean (bits/s)	95% (bits/s)
Packet mode	Access	4800	FFS
	Transit	4800	FFS

NOTES

1 All values in table 31 are provisional.

2 Intended use, applicability, and general assumptions relevant to these objectives are discussed in 8.1 of ANSI T1.504b.

3 If a satellite link is used in a connection portion, then to achieve an ISDN packet mode throughput capacity of 4800 bits/s or better, a packet layer window size greater than 2 and data link layer window size greater than 7 is required.

4 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.

5.1.4 Clear indication delay

5.1.4.1 Definition of clear indication delay

Clear indication delay as defined in 4.4 of ANSI T1.504 (see also 8.2 of ANSI T1.504b) applies to ISDN packet mode service. The end-to-end clear indication delay (shown as d in figure 16) is the one-way delay between the NI/T boundaries. The access portion clear indication delay is the delay between the boundaries delimiting an access portion. The transit portion clear indication delay is the delay between the boundaries delimiting a transit portion.

NOTE – ISDN protocols operating on the D or B channels (e.g., ANSI T1.607) may allow alternative call clearing procedures to be used. Definition and specification of clear indication delay with respect to these alternative procedures are for further study.

5.1.4.2 Clear indication delay objectives

Table 32 specifies the objectives for ISDN packet mode clear indication delay for each of the portion types defined in 3.1. All values are based on (and only apply under) the following assumptions:

- data link layer windows on the receiving side of the portion being specified are open (i.e., not flow controlled);
- the extended format of the clear request packet is not used;
- ISDN access is used at both ends of the call.

Table 32 – Worst-case performance objectives for ISDN packet mode clear indication delay

ISDN connection type	Portion type	Statistic	
		Mean (ms)	95% (ms) ¹⁾
Packet mode	Access; Nominal interconnection	685 + Z	FFS
	Access; Cooperatively planned interconnection	375 + Z	FFS
	Transit	300	FFS
<p>NOTES</p> <p>1 The value of Z depends on the signaling rate of the channel (B or D) and is defined in table 20 of ANSI T1.504b. On the BRI D-channel, Z = 5 ms. On a 64 kbit/s channel, Z = 1.25 ms.</p> <p>2 Intended use, applicability, and general assumptions relevant to these objectives are discussed in 8.1 of ANSI T1.504b. As a consequence of increased integration of the ISDN packet handler and the public packet-switched network, the performance objectives specified in ANSI T1.517 will be revised in the future.</p> <p>3 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.</p> <p>¹⁾ It is expected that 95 percent of the measured clear indication delays will fall within the range $[0, \mu + 2\mu]$, where μ is the mean clear indication delay.</p>			

5.2 Accuracy and dependability parameters and objectives

This subclause specifies for ISDN packet mode bearer services accuracy and dependability parameters that can be measured or estimated between any pair of boundaries delimiting a portion or concatenation of portions.

5.2.1 Access parameters

Two access parameters (call set-up error probability and call set-up failure probability) are defined in 5.2.1.

5.2.1.1 Call set-up error probability

5.2.1.1.1 Definition of call set-up error probability

Call set-up error probability as defined in 5.1.1 of ANSI T1.504 (see also 8.2 of ANSI T1.504b) applies to ISDN packet mode service when call set-up procedures associated with case 2 (see 5.1.1.1.2) are used.

NOTE – Call set-up error probability associated with case 1 (see 5.1.1.1.1) is for further study.

5.2.1.1.2 Call set-up error objectives

Table 33 specifies the objectives for ISDN packet mode call set-up error objectives for each of the portion types defined in 3.1.

Table 33 – Worst-case performance objectives for ISDN packet mode call set-up error probability

ISDN connection type	Portion type	Statistic
		Probability
Packet mode	Access	1×10^{-5}
	Transit	1×10^{-5}
NOTES 1 Intended use, applicability, and general assumptions relevant to these objectives are discussed in 8.1 of ANSI T1.504b. 2 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.		

5.2.1.2 Call set-up failure probability

5.2.1.2.1 Definition of call set-up failure probability

Call set-up failure probability as defined in 5.1.2 of ANSI T1.504 (see also 8.2 of ANSI T1.504b) applies to ISDN packet mode service when call set-up procedures associated with case 2 (see 5.1.1.1.2) are used.

NOTE – Call set-up failure probability associated with case 1 (see 5.1.1.1.1) is for further study.

5.2.1.2.2 Call set-up failure objectives

Table 34 specifies the objectives for ISDN packet mode call set-up failure objectives for each of the portion types defined in 3.1. All values are based on (and only apply under) the following assumptions:

- data link and packet layer windows on the receiving side of the portion being specified are open (i.e., not flow controlled);
- ISDN access is used at both ends of the call.

Table 34 – Worst-case performance objectives for ISDN packet mode call set-up failure probability

ISDN connection type	Portion type	Statistic
		Probability
Packet mode	Access	5×10^{-3}
	Transit	5×10^{-3}
NOTES 1 Intended use, applicability, and general assumptions relevant to these objectives are discussed in 8.1 of ANSI T1.504b. 2 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.		

5.2.2 User information transfer parameters

Five user information transfer parameters (residual error ratio, reset stimulus probability, reset probability, premature disconnect stimulus probability, premature disconnect probability) are defined in 5.2.2.

5.2.2.1 Residual error ratio

5.2.2.1.1 Definition of residual error ratio

Residual error ratio as defined in 5.2.1 of ANSI T1.504 (see also 8.2 of ANSI T1.504b) applies to ISDN packet mode service.

5.2.2.1.2 Residual error ratio objectives

Table 35 specifies the objectives for ISDN packet mode residual error ratio objectives for each of the portion types defined in 3.1. All values are based on (and only apply under) the following assumption:

- a user information field length of 128 octets.

Table 35 – Worst-case performance objectives for ISDN packet mode residual error ratio

ISDN connection type	Portion type	Statistic
		Ratio
Packet mode	Access	1×10^{-9}
	Transit	1×10^{-9}
NOTES 1 Intended use, applicability, and general assumptions relevant to these objectives are discussed in 8.1 of ANSI T1.504b. 2 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.		

5.2.2.2 Reset stimulus probability

5.2.2.2.1 Definition of reset stimulus probability

Reset stimulus probability as defined in 5.2.2 of ANSI T1.504 (see also 8.2 of ANSI T1.504b) applies to ISDN packet mode service.

5.2.2.2.2 Reset stimulus probability objectives

Table 36 specifies the objectives for ISDN packet mode reset stimulus probability objectives for each of the portion types defined in 3.1.

Table 36 – Worst-case performance objectives for ISDN packet mode reset stimulus probability

ISDN connection type	Portion type	Statistic
		Probability
Packet mode	Access	1×10^{-6}
	Transit	1×10^{-6}
NOTES 1 The probability is the reset stimuli per virtual connection second. 2 Intended use, applicability, and general assumptions relevant to these objectives are discussed in 8.1 of ANSI T1.504b. 3 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.		

5.2.2.3 Reset probability

5.2.2.3.1 Definition of reset probability

Reset probability as defined in 5.2.2 of ANSI T1.504 (see also 8.2 of ANSI T1.504b) applies to ISDN packet mode service.

5.2.2.3.2 Reset probability objectives

Table 37 specifies the objectives for ISDN packet mode reset probability objectives for each of the portion types defined in 3.1.

Table 37 – Worst-case performance objectives for ISDN packet mode reset probability

ISDN connection type	Portion type	Statistic
		Probability
Packet mode	Access	5×10^{-6}
	Transit	5×10^{-6}
NOTES 1 The probability is the resets per virtual connection second. 2 Intended use, applicability, and general assumptions relevant to these objectives are discussed in 8.1 of ANSI T1.504b. 3 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.		

5.2.2.4 Premature disconnect stimulus probability

5.2.2.4.1 Definition of premature disconnect stimulus probability

Premature disconnect stimulus probability as defined in 5.2.3 of ANSI T1.504 (see also 8.2 of ANSI T1.504b) applies to ISDN packet mode service.

NOTE – Performance-significant reference events associated with ISDN protocols operating on the D or B channels (e.g., ANSI T1.607) may cause the occurrence of premature disconnect stimuli. The need for and definition of such reference events relevant to the definition of premature disconnect stimulus probability are for further study.

5.2.2.4.2 Premature disconnect stimulus probability objectives

Table 38 specifies the objectives for ISDN packet mode premature disconnect stimulus probability objectives for each of the portion types defined in 3.1.

Table 38 – Worst-case performance objectives for ISDN packet mode premature disconnect stimulus probability

ISDN connection type	Portion type	Statistic
		Probability
Packet mode	Access	1×10^{-7}
	Transit	1×10^{-7}
<p>NOTES</p> <p>1 The probability is the premature disconnect stimuli per virtual connection second.</p> <p>2 Intended use, applicability, and general assumptions relevant to these objectives are discussed in 8.1 of ANSI T1.504b.</p> <p>3 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.</p>		

5.2.2.5 Premature disconnect probability

5.2.2.5.1 Definition of premature disconnect probability

Premature disconnect probability as defined in 5.2.3 of ANSI T1.504 (see also 8.2 of ANSI T1.504b) applies to ISDN packet mode service.

NOTE – Performance-significant reference events associated with ISDN protocols operating on the D or B channels (e.g., ANSI T1.607) may cause the occurrence of premature disconnects. The need for and definition of such reference events relevant to the definition of premature disconnect probability are for further study.

5.2.2.5.2 Premature disconnect probability objectives

Table 39 specifies the objectives for ISDN packet mode premature disconnect probability objectives for each of the portion types defined in 3.1.

Table 39 – Worst-case performance objectives for ISDN packet mode premature disconnect probability

ISDN connection type	Portion type	Statistic
		Probability
Packet mode	Access	3×10^{-6}
	Transit	3×10^{-6}
<p>NOTES</p> <p>1 The probability is the premature disconnects per virtual connection second.</p> <p>2 Intended use, applicability, and general assumptions relevant to these objectives are discussed in 8.1 of ANSI T1.504b.</p> <p>3 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.</p>		

5.2.3 Disengagement performance – Call clear failure probability

5.2.3.1 Definition of call clear failure probability

Call clear failure probability as defined in 5.3 of ANSI T1.504 (see also 8.2 of ANSI T1.504b) applies to ISDN packet mode service.

NOTE – ISDN protocols operating on the D or B channels (e.g., ANSI T1.607) may allow alternative call-clearing procedures to be used. Definition and specification of call clear failure probability with respect to these alternative procedures are for further study.

5.2.3.2 Call clear failure probability objectives

Table 40 specifies the objectives for ISDN packet mode call clear failure probability objectives for each of the portion types defined in 3.1. All values are based on (and only apply under) the following assumptions:

- data link layer windows on the receiving side of the portion being specified are open (i.e., not flow controlled);
- the extended format of the clear request packet is not used;
- ISDN access is used at both ends of the call.

Table 40 – Worst-case performance objectives for ISDN packet mode call clear failure probability

ISDN connection type	Portion type	Statistic
		Probability
Packet mode	Access	1×10^{-5}
	Transit	1×10^{-5}
NOTES 1 Intended use, applicability, and general assumptions relevant to these objectives are discussed in 8.1 of ANSI T1.504b. 2 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.		

5.3 Availability parameters and objectives

Two availability parameters (service availability and mean time between service outages) are defined in 5.3.

5.3.1 Availability function

The availability function as defined in 6.1 of ANSI T1.504 (see also 8.2 of ANSI T1.504b) applies to ISDN packet mode service.

5.3.2 Service availability

5.3.2.1 Definition of service availability

Service availability, as defined in 6.2 of ANSI T1.504 (see also 8.2 of ANSI T1.504b), applies to ISDN packet mode service.

5.3.2.2 Service availability objectives

Table 41 specifies the objectives for ISDN packet mode service availability for each of the portion types defined in 3.1. All values are based on (and only apply under) the same assumptions used in specifying the primary parameters.

Table 41 – Worst-case performance objectives for ISDN packet mode service availability

ISDN connection type	Portion type	Statistic
		Percent
Packet mode	Access	99.7
	Transit	99.7
<p>NOTES</p> <p>1 Intended use, applicability, and general assumptions relevant to these objectives are discussed in 8.1 of ANSI T1.504b.</p> <p>2 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.</p>		

5.3.3 Mean time between service outages

5.3.3.1 Definition of mean time between service outages

Mean time between service outages, as defined in 6.2 of ANSI T1.504 (see also 8.2 of ANSI T1.504b), applies to ISDN packet mode service.

5.3.3.2 Mean time between service outages objectives

Table 42 specifies the objectives for ISDN packet mode mean time between service outages for each of the portion types defined in 3.1. All values are based on (and only apply under) the same assumptions used in specifying the primary parameters.

Table 42 – Worst-case performance objectives for ISDN packet mode mean time between service outages

ISDN connection type	Portion type	Statistic
		Hours
Packet mode	Access	1300
	Transit	1300
<p>NOTES</p> <p>1 Intended use, applicability, and general assumptions relevant to these objectives are discussed in 8.1 of ANSI T1.504b.</p> <p>2 Example methods for calculating end-to-end values for concatenations of access and transit portions are described in annex A of ANSI T1.504b.</p>		

5.3.4 Related parameters

Related parameters, as defined in 6.2 of ANSI T1.504 (see also 8.2 of ANSI T1.504b), apply to ISDN packet mode service.

Annex A
(informative)

Bibliography

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ANSI X3.102-1990, *Information systems – Data communication systems and services – User-oriented performance parameters*

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⁵⁾ Available from Alliance for Telecommunications Industry Solutions, 1200 G Street, NW, Suite 500, Washington, DC 20005.