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ATIS-0100511.2003(R2013)

B-ISDN ATM Layer Cell Transfer

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ATIS-0100511.2003(R2013), *B-ISDN ATM Layer Cell Transfer*

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American National Standard for Telecommunications

B-ISDN ATM Layer Cell Transfer Performance

Secretariat

Alliance for Telecommunications Industry Solutions

Approved February 28, 2003

American National Standards Institute, Inc.

Abstract

Through its normative reference to ITU-T Recommendation I.356, this standard defines speed, accuracy, and dependability performance parameters for cell transfer in the Asynchronous Transfer Mode (ATM) layer of a national public Broadband Integrated Services Digital Network (B-ISDN). It provisionally allocates performance values to defined portions of an end-to-end national ATM connection.

Foreword

The information contained in this Foreword is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, this Foreword may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the standard.

Accredited Standards Committee T1, Telecommunications serves the public through improved understanding between carriers, customers, and manufacturers. Technical Subcommittee T1A1 of Committee T1 develops telecommunications standards and technical reports related to performance, reliability, and associated security aspects of communications networks, as well as the processing of voice, audio, data, image, and video signals, and their multimedia integration.

ANSI guidelines specify two categories of requirements: mandatory and recommendation. The mandatory requirements are designated by the word *shall* and recommendations by the word *should*. Where both a mandatory requirement and a recommendation are specified for the same criterion, the recommendation represents a goal currently identifiable as having distinct compatibility or performance advantages.

Suggestions for improvement of this standard are welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, T1 Secretariat, 1200 G Street NW, Suite 500, Washington, DC 20005.

This standard was processed and approved for submittal to ANSI by Accredited Standards Committee on Telecommunications, T1. Committee approval of the standard does not necessarily imply that all members voted for its approval. At the time it approved this standard, the T1 Committee had the following members:

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American National Standard for Telecommunications –

B-ISDN ATM Layer Cell Transfer Performance

1 Scope

This American National Standard:

a) Defines speed, accuracy, and dependability performance parameters for cell transfer in the Asynchronous Transfer Mode (ATM) layer of a national public Broadband Integrated Services Digital Network (B-ISDN) through its normative reference to ITU-T Recommendation I.356; [1]

b) Defines a national ATM performance model and provisionally allocates the ITU-T Recommendation I.356 performance values to defined portions of an end-to-end national ATM connection;

c) Provides supplemental information intended to assist performance characterization of national ATM services.

The network performance (NP) parameters and provisional allocations specified in T1.511-2003 apply to national public end-to-end point-to-point ATM connections and to designated portions of such connections when provided in accordance with the normative references (clause 2) and the requirements (clause 3) of this standard. The parameters are defined on the basis of ATM cell transfer reference events that may be observed at physical interfaces between ATM networks and associated customer equipment, and at physical interfaces between ATM networks.[2]

T1.511-2003 is intended to be used in the planning and offering of national B-ISDN ATM services. The intended users of this standard include ATM service providers, equipment manufacturers, and end users. This standard may be used by service providers in the planning, development, and assessment of ATM services that meet user performance needs, by equipment manufacturers as performance metrics that will affect equipment design, and by end users in evaluating performance.

The scope of T1.511-2003 is summarized in Figure 1. The ATM performance parameters are defined on the basis of ATM cell transfer reference events that may be observed at physical interfaces associated with specified boundaries. For comparability and completeness, ATM performance is considered in the context of the 3 x 3 performance matrix defined in ANSI X3.102, *American National Standard for Information systems – Data communication systems and services – User-oriented performance*

[1] ITU-T Recommendation I.356: (1) defines parameters for quantifying the ATM cell transfer performance of an international B-ISDN connection (including adjusted parameter definitions that might be used when cells do not conform with the ITU-T Recommendation I.371-negotiated traffic contract); (2) specifies provisional international performance objectives for cell transfer, some of which depend on the user's selection of QoS class; (3) defines QoS classes; and (4) allocates provisional performance objectives to the individual national portions in providing an international B-ISDN ATM connection.

[2] ITU-T Recommendation I.353 defines performance-significant reference events upon which the ITU-T Recommendation I.356 parameter definitions are based.

parameters. Three protocol-independent communication functions are identified in the matrix: 1) access; 2) user information transfer; and 3) disengagement. Each function is considered with respect to three general performance concerns (or "performance criteria"): 1) speed; 2) accuracy; and 3) dependability. T1.511-2003 characterizes the speed, accuracy, and dependability of user information transfer provided by national public ATM networks. Planned American National Standards will define cell transfer availability parameters, and provide standard methods of measuring the cell transfer performance parameters in a national context. The national performance of the ATM layer access and disengagement functions, as well as the availability performance of switched B-ISDN services, will be addressed in separate ANSI standards.

T1.511-2003 is structured as follows. Clause 1 specifies the scope of the standard. Clause 2 specifies its normative references. Clause 3 specifies its requirements, many of which are direct references to ITU-T Recommendation I.356. Clause 4 specifies the national ATM performance model. Clause 5 specifies the (provisional) national ATM cell transfer performance allocations. Clause 6 specifies bringing-into-service (BIS) criteria for voice virtual channels. The informative annexes provide supplemental (i.e., non-normative) information intended to assist application of ITU-T Recommendation I.356 and T1.511-2003.

NOTES

1 Consistent by reference to ITU-T Recommendation I.356, the T1.511-2003 parameters may be augmented or modified based upon further study of the requirements of the services to be supported on B-ISDNs.

2 Consistent by reference to ITU-T Recommendation I.356, the T1.511-2003 parameters are intended to characterize ATM connections in the available state.

3 Consistent by reference to ITU-T Recommendation I.356, the T1.511-2003 parameters apply to cell streams in which all cells conform with the negotiated ITU-T Recommendation I.371 traffic contract.

4 The recommended ATM performance values to be achieved nationally for each of the defined parameters depend on which Quality of Service (QoS) class the end-users and network providers agree upon for the connection. T1.511-2003 (clause 5) uses the four QoS classes defined in ITU-T Recommendation I.356 (§8).

5 Consistent by reference to ITU-T Recommendation I.356, the T1.511-2003 parameters are equally applicable to national virtual channel connections (VCCs) and national virtual path connections (VPCs). The national allocations in clause 5 are also applicable to both VCCs and VPCs. However, the end users (customers) of a national VPC will often be two networks that use the VPC to support individual VCCs. In order to meet the end-to-end values on each VCC, the performance of the supporting VPC must be better. The degree to which the VPC performance must be better than VCC performance is for further study.

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 edition of the standards indicated below.

T1.514-2001, *Network performance parameters and objectives for dedicated digital services – SONET bit rates.* [3]

T1.627-1993 (R1999), *Broadband ISDN – ATM layer functionality and specification.* [3]

T1.654-1996, *Broadband integrated services digital network (B-ISDN) operations and maintenance principles and functions.* [3]

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3 This document is available from the Alliance for Telecommunications Industry Solutions, 1200 G Street N.W., Suite 500, Washington, DC 20005. <http://www.atis.org>.

ANSI X3.102-1992, *Information systems – Data communication systems and services – User-oriented performance parameters.*[4]

ITU-T Recommendation G.711*, Pulse code modulation (PCM) of voice frequencies*, 1988.[5]

ITU-T Recommendation I.353*, Reference events for defining ISDN and B-ISDN performance parameters*, 1996.[5]

ITU-T Recommendation I.356, *B-ISDN ATM layer cell transfer performance*, 2000.[5]

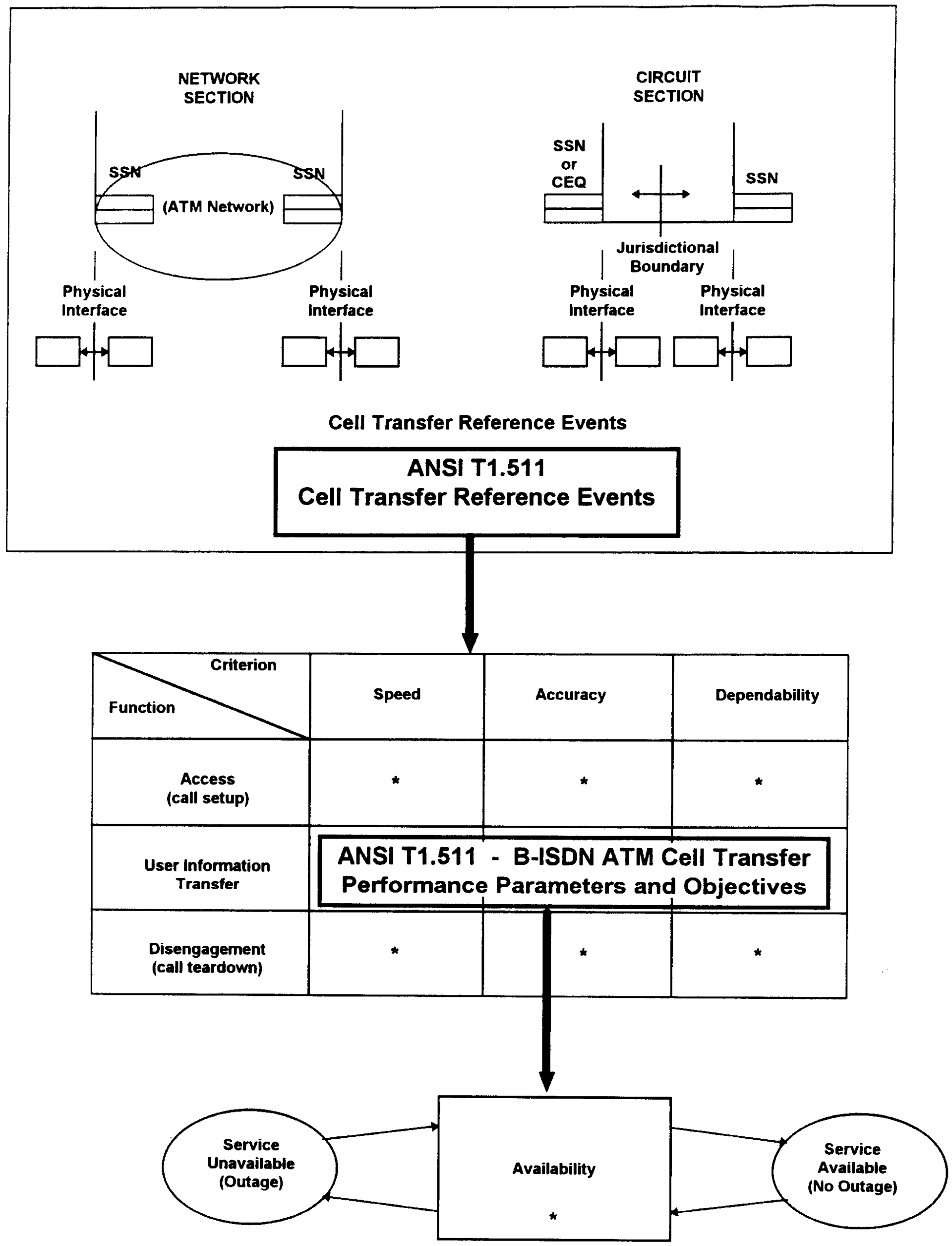
ITU-T Recommendation I.371, *Traffic control and congestion control in B-ISDN*, 1996.[5]

ITU-T Recommendation M.2201*, Performance objectives, allocations and limits for bringing-into-service and maintenance of international ATM virtual path and virtual channel connections*, 2001.[5]

ITU- T Recommendation Q.2931, *B-ISDN. Digital subscriber signalling system no. 2 (DSS 2). User-network interface (UNI) layer 3 specification for basic call/connection control*, 1996.[5]

[4] Available from American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036.

[5] This document is available from the International Telecommunications Union.
< http://www.itu.int/ITU-T/ >



* Subject of planned ANSI supplements or standards.

Figure 1 - Scope of T1.511-2003

3 Requirements

The American National Standard for B-ISDN ATM layer cell transfer performance shall be the text of ITU-T Recommendation I.356, *B-ISDN ATM layer cell transfer performance*, 1996, with the modifications specified in this clause. [6]

NOTE – The informative annex of T1.511-2003 provides supplemental information intended to assist application of ITU-T Recommendation I.356 and T1.511-2003.

The following subclauses highlight the applicability of individual sections from ITU-T Recommendation I.356.

3.1 Scope

The scope of T1.511-2003 (clause 1) replaces the scope of ITU-T Recommendation I.356 (§1).

3.2 References

The normative references of T1.511-2003 (clause 2) replace the references of ITU-T Recommendation I.356 (§2).

3.3 Abbreviations & Acronyms

All of the abbreviations in ITU-T Recommendation I.356 apply in T1.511-2003. Abbreviations used in the T1.511-2003 text are:

1-point CDV *or* 1-pt CDV	1-point Cell Delay Variation at an MP
2-point CDV *or* 2-pt CDV	2-point Cell Delay Variation between two Mps
AAL	ATM Adaptation Layer
ABR	Available Bit Rate
ACS	Access Circuit Section
ANS	Access Network Section
ANSI	American National Standards Institute
ATC	ATM Transfer Capability
ATM	Asynchronous Transfer Mode
AU	Administration Unit
BIS	Bringing-Into-Service
B-ISDN	Broadband Integrated Services Digital Network

6 Unless indicated otherwise in this standard, T1.511-2003 also incorporates the relevant text of ITU-T Recommendations normatively referenced by ITU-T Recommendation I.356.

BISPO	BIS Performance Objective
B-NT1	Broadband-Network Termination 1
B-NT2	Broadband-Network Termination 2
B-TE	Broadband-Terminal Equipment
CBR	Constant Bit Rate
CDV	Cell Delay Variation
CEQ	Customer Equipment/Customer Network
CER	Cell Error Ratio
CLR	Cell Loss Ratio
CLR_0	Cell Loss Ratio for the high priority cells
CLR_{0+1}	Cell Loss Ratio for the aggregate cell stream
CLR_1	Cell Loss Ratio for the low priority cells
CMR	Cell Misinsertion Rate
CTD	Cell Transfer Delay
DBR	Deterministic Bit Rate
DSn	Digital Signal level n
ICS	Internetwork Circuit Section
IEC	Interexchange Carrier
INI	Internetwork Interface
ITP	International Transit Portion
ITU-T	International Telecommunication Union – Telecommunication Standardization Sector
LEC	Local Exchange Carrier
MP	Measurement Point
MPI	International Measurement Point
MP_{INI}	MP at an INI
MP_{NI}	MP at an NI
MPT	Measurement Point at T_B
NI	Network Interface
NP	Network Performance
NPC	Network Parameter Control
OC	Optical Carrier
PCR	Peak Cell Rate
PDH	Plesiochronous Digital Hierarchy
PVC	Permanent Virtual Channel
QoS	Quality of Service
SDH	Synchronous Digital Hierarchy
SECB	Severely Errored Cell Block
SECBR	Severely Errored Cell Block Ratio
SONET	Synchronous Optical NETwork
SPRT	Sequential Probability Ratio Test

SSN	Switching/Signaling Node
STS	Synchronous Transport Signal
SVC	Switched Virtual Channel
TNS	Transit Network Section
TU	Tributary Unit
UPC	Usage Parameter Control
VC	Virtual Channel
VCC	Virtual Channel Connection
VP	Virtual Path
VPC	Virtual Path Connection
VT	Virtual Tributary

3.4 Performance model

Clause 4 of this standard extends the performance model of ITU-T Recommendation I.356 (§3) to the national context.

3.5 ATM cell transfer outcomes

The cell transfer outcomes defined in ITU-T Recommendation I.356 (§5) apply in the national context of T1.511-2003. These outcomes are:

– Successfully transferred cell outcome;
– Errored cell outcome;
– Tagged cell outcome;
– Misinserted cell outcome;
– Lost cell outcome; and
– Severely errored cell block outcome.

See Annex A for clarification concerning the tagged cell outcome.

3.6 ATM performance parameters

The ATM performance parameters defined in ITU-T Recommendation I.356 (§6) apply in the national context of T1.511-2003. These parameters are:

– Cell error ratio (CER);
– Cell loss ratio for the high priority cells (CLR_0);
– Cell loss ratio for the aggregate cell stream (CLR_{0+1});
– Cell loss ratio for the low priority cells (CLR_1);

- Cell misinsertion rate (CMR);
- Severely errored cell block ratio (SECBR);
- Cell transfer delay (CTD);
- 1-point cell delay variation at an MP (1-point CDV); and
- 2-point cell delay variation between two MPs (2-point CDV).

3.7 Network performance when some cells are non-conforming

ITU-T Recommendation I.356 (§7) does not place any requirements on network operators and, in particular, does not include any requirements for national networks. The material in ITU-T Recommendation I.356 (§7) illustrates one way of extending the ATM performance parameter definitions and measurement methods to cell streams in which some cells do not conform with the negotiated traffic contract. (See Annex A for more information.)

3.8 Network performance objectives

The ATM QoS classes defined in ITU-T Recommendation I.356 (§8) apply in the national context of T1.511-2003. These QoS classes are:

- Class 1 (stringent class);
- Class 2 (tolerant class);
- Class 3 (bi-level class); and
- Class U (unbounded/unspecified class).

ITU-T Recommendation I.356 (§8) includes numeric objectives for certain performance parameters applicable to end-to-end international connections. The national performance allocations specified in T1.511-2003 (clause 5) are consistent with the ITU-T Recommendation I.356 objectives. No objectives are specified for CLR_1 or 1-point CDV.

3.9 Allocation of the performance objectives

ITU-T Recommendation I.356 (§9) includes allocations of the ITU-T Recommendation I.356 (§8) performance objectives to the national portions of an end-to-end international ATM connection. The performance allocations specified within the national context of T1.511-2003 (clause 5) are consistent with these allocations.

3.10 Relationship between ATM layer NP and the NP of AAL type 1 for CBR services

The network performance relationships described in ITU-T Recommendation I.356 (Annex A) apply in the national context of T1.511-2003.

3.11 Cell transfer delay, 1-point CDV, and 2-point CDV characteristics

The cell transfer performance characteristics described in ITU-T Recommendation I.356 (Annex B) apply in the national context T1.511-2003.

3.12 Cell transfer performance measurement methods

The measurement methods described in ITU-T Recommendation I.356 (Annex C) apply in the national context T1.511-2003.

3.13 Assessing the performance of a UPC/NPC mechanism

Appendix I of ITU-T Recommendation I.356 is not part of T1.511-2003.

3.14 Hypothetical reference connections for validating the ATM performance objectives

Appendix II of ITU-T Recommendation I.356 is not part of T1.511-2003.

3.15 Example applications of the allocation rules of ITU-T Recommendation I.356 (§9.5, §9.6, §9.7)

Appendix III of ITU-T Recommendation I.356 is not part of T1.511-2003.

4 National ATM performance model

This clause defines an ATM performance model that extends the performance model defined in ITU-T Recommendation I.356 (§4) to provide a basis for national ATM layer cell transfer performance definition and specification. The layered nature of B-ISDN performance issues is illustrated in Figure 3/I.356 of ITU-T Recommendation I.356. [7]

4.1 Performance model

The national ATM performance model comprises an ATM reference configuration, jurisdictional boundaries, associated access and transit connection portions, and a set of performance-significant reference events. As shown in Figure 2, a representative end-to-end national B-ISDN ATM connection consists of two access portions and an intervening transit portion. Although other jurisdictional arrangements are possible, an access portion generally comprises facilities provided by an “exchange

[7] For national ATM performance allocation purposes, physical layer (e.g., SONET) performance is allocated in accordance with T1.514-2001. The need for additional physical layer performance parameters and definitions is for further study.

carrier" and a transit portion generally comprises facilities provided by an "inter-exchange carrier."[8] Performance allocations 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 measurement points that may serve as practical surrogates for the jurisdictional boundaries. ATM network performance may be estimated from observations of cell transfer reference events made at or near measurement points associated at or near the jurisdictional and section boundaries.

4.2 Definitions

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

4.2.1 Jurisdictional terms

4.2.1.1 jurisdictional boundary: Either a network interface or an internetwork interface.

4.2.1.1.1 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 ATM performance responsibilities between the customer and the network service provider. The B-ISDN T_B reference point, which separates the B-NT1 and B-TE (or B-NT2), is considered coincident with the NI.

4.2.1.1.2 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 ATM performance responsibilities between the access network and the transit network providers.

8 It is recognized that future revisions to T1.511-2003 will need to address evolving jurisdictional arrangements (e.g., unbundling requirements – see T1.TR.51-1996).

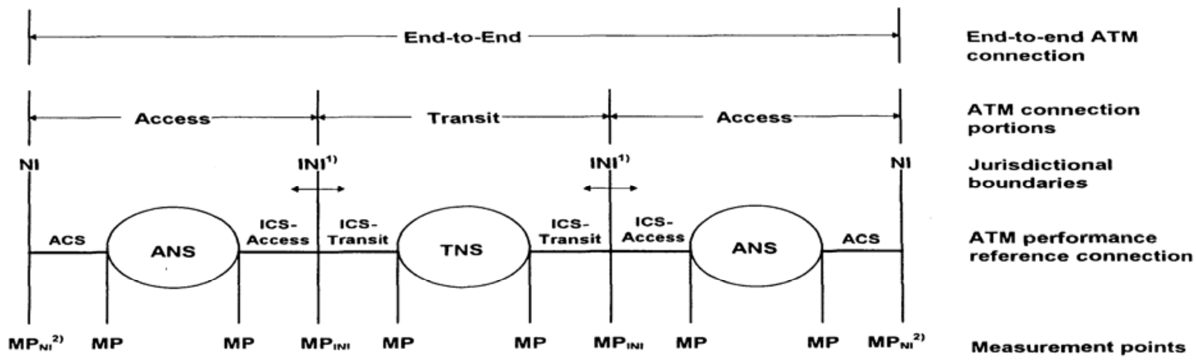


Figure 2 - National ATM performance model

Legend:	
ACS = Access circuit section	MP = Measurement point
ANS = Access network section	NI = Network interface
ICS = Internetwork circuit section	TNS = Transit network section
INI = Internetwork interface	
1) Location of the INI depends on arrangements among the service providers.	
2) An MP_{NI} may be coincident with the NI or may be created at the NI by an attached B-TE.	

4.2.1.2 access portion: The access portion is a jurisdictional portion of an end-to-end ATM connection between an NI and the closest INI. An access portion carries user information and signaling information between the network and internetwork interfaces. An access portion typically includes an access circuit section, an access network section, and part of an internetwork circuit section.

4.2.1.3 transit portion: The transit portion is a jurisdictional portion of an end-to-end ATM connection between two INIs. The transit portion carries user information and signaling between the two internetwork interfaces. The transit portion normally includes a transit network section and parts of two internetwork circuit sections.

NOTE – The definitions of access portion and transit portion are subject to substantial change as the Telecommunications Act of 1996 is implemented.

4.2.2 Functional terms

4.2.2.1 circuit section: Either an access circuit section or an internetwork circuit section.

4.2.2.1.1 access circuit section (ACS): The physical circuit or set of circuits connecting a customer equipment/customer network (CEQ) to the (local) switching/signaling node (SSN). It does not include any parts of the CEQ or SSN.

4.2.2.1.2 internetwork circuit section (ICS): The physical circuit or set of circuits connecting an SSN in one jurisdiction with an SSN in another jurisdiction. Note that jurisdiction over an ICS may be split between the two network providers.

4.2.2.2 network section: The network components that provide the connection between two circuit sections. A network section may be either an access network section or a transit network section.

4.2.2.2.1 access network section (ANS): A network section between an ACS and an ICS, or between two ACSs.

4.2.2.2.2 transit network section (TNS): A network section between two ICSs.

4.2.2.3 basic section of a connection: A general term for an ACS, ICS, ANS, or a TNS.

4.2.2.4 section boundary: The boundary between a network section and an adjacent circuit section, or between an ACS and the adjacent CEQ.

4.2.3 measurement point (MP): A boundary at which protocols defined in American National Standards can be observed. MPs exist at both functional (section) boundaries and jurisdictional boundaries.

NOTE – As defined, MPs exist at many interfaces in a connection. It is not the intention of this standard to specify performance between arbitrary pairs of MPs – particularly MPs within an access or transit portion. This standard will only specify the performance of portions delimited by jurisdictional boundaries, MP_{NI} and/or MP_{INI}.

4.2.3.1 measurement point NI (MP_{NI}): The MP_{NI} is the MP located at the NI.

4.2.3.2 measurement point INI (MP_{INI}): The MP_{INI} is the MP located at the INI.

4.3 Cell transfer reference events

Through its reference to ITU-T Recommendation I.356 (§3), the cell transfer reference event A1 defined in ITU-T Recommendation I.353 (Table 8/I.353) is adapted to the national context of T1.511-2003.

The definition of the cell transfer reference event in ITU-T Recommendation I.353 is extended by T1.511-2003 for use at the jurisdictional boundaries, MP_{NI} and the MP_{INI}. This extension enables T1.511-2003 to apply the ITU-T Recommendation I.356 performance parameters between national jurisdictional boundaries as well as between functional boundaries. The extension of the definition of cell transfer reference event is accomplished by assuming that the attached CEQ or SSN is exactly adjacent to the jurisdictional boundary, whether it is or not. This concept is illustrated in Figure 3, which shows test equipment (hypothetically) located exactly at the MP_{NI} and the MP_{INI}. Then, as defined in ITU-T Recommendation I.353 (§3.9), the exit and entry events are taken to be the multiplexing/demultiplexing of cells within the ATM layer of the (hypothetical) test equipment. [9]

9 ITU-T Recommendation I.353 (§3.9) defines ATM cell transfer reference events for virtual path (VP) and virtual channel (VC) connections.

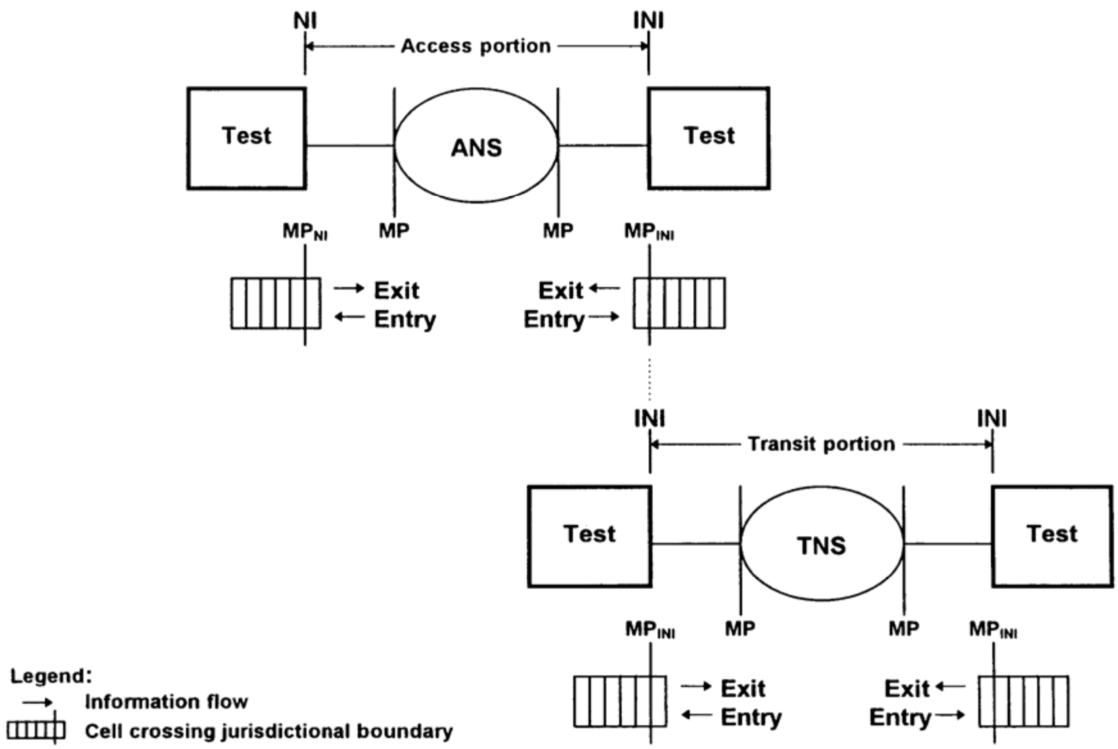


Figure 3 - Definition of cell reference events at the NI and INI boundaries

NOTE – As noted in ITU-T Recommendation I.353, for practical measurement purposes, ATM cell transfer reference events need not be observed within the ATM protocol layer of the CEQ or SSN. Instead, the time of occurrence of these reference events can be approximated by observing the cells crossing an associated physical interface. This physical interface should, however, be as near as possible to the desired MP. In cases where reference events are monitored at a physical interface, the time of occurrence of an exit event can best be approximated by the observation of the first bit of the cell coming from the SSN, CEQ, or test equipment. The time of occurrence of an entry event can best be approximated by the observation of the last bit of the cell going to the SSN, CEQ, or test equipment.

5 National network performance allocations

This clause specifies provisional worst-case network performance allocations for user information transfer of ATM cells in national public B-ISDNs. The allocations are stated in terms of the ATM layer performance parameters defined in ITU-T Recommendation I.356 (§6) and apply within the context of the national ATM performance model defined in clause 4.[10] A summary of the allocations can be found in Table 1 together with its associated general notes. All values in Table 1 are provisional and they need not be met until they are revised (up or down) based on real operational experience.

NOTE – Conditions under which worst-case network performance allocations do not apply are for further study.

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10 Some network providers may support performance allocations even when some cells are non-conforming. In these cases, the adjusted parameter definitions of ITU-T Recommendation I.356 (§7) are one way of comparing network performance with the numeric allocations of clause 5.

The performance allocations specified in T1.511-2003 differ from other ANSI performance standards because: (1) the user has the option of requesting a different QoS for each new VP and VC connection; and (2) for some QoS classes and certain performance parameters, no minimum level of quality will be specified in this standard.

The ATM QoS classes defined in ITU-T Recommendation I.356 (§8.1 and §8.2) are adapted to the national context of T1.511-2003. Table 1 presents the performance allocations that network providers shall achieve in support of these QoS classes.

5.1 Nature of the national ATM performance allocations

When supporting a negotiated QoS class, providers of national public B-ISDN ATM connections shall support the provisional allocations in Table 1. This will ensure suitable performance for end-to-end domestic connections and will enable the national and transit country objectives specified in ITU-T Recommendation I.356 (§4 and §9) to be met for international connections.

Table 1 - Provisional national ATM network portion performance allocations

	CTD (note 7) (note 8)	**2-pt CDV**	**CLR_{0+1}**	**CLR_0**	**CER**	**CMR**	**SECBR**
Nature of the Network Portion Performance Allocation:	upper bound on the mean CTD	upper bound on the difference between upper and lower 10^{-8} quantiles of CTD	upper bound on the cell loss probability	upper bound on the cell loss probability	upper bound on the cell error probability	upper bound on the mean CMR	upper bound on the SECB probability
Default Allocations:	no default	no default	no default	no default	4×10^{-6} (note 1)	1 per day (note 2)	10^{-4} (note 3)

Access Portion

Default Allocations:	no default	no default	no default	no default	6×10^{-7}	2 per 216 hours	1.5×10^{-5}
for class 1	10 ms (note 6)	1.3 ms (note 4)	5×10^{-8} (note 5)	none	default	default	default
for class 2	U	U	2.5×10^{-6}	none	default	default	default
for class 3	U	U	U	2.5×10^{-6}	default	default	default
for class 4	U	U	U	U	U	U	U
for class 5	10 ms (note 6)	2.6 ms (note 4)	None	5×10^{-8} (note 5)	default	default	default

Transit Portion

default allocation	no default	no default	no default	no default	6 x 10^{-7}	1 per 216 hours	1.5 x 10^{-5}
for class 1	45 ms (note 6)	0.7 ms (note 4)	5x10^{-8} (note 5)	none	default	default	default
for class 2	U	U	1 x 10^{-6}	none	default	default	default
for class 3	U	U	U	1 x 10^{-6}	default	default	default
for class 4	U	U	U	U	U	U	U
for class 5	45 ms (note 6)	1.4 ms (note 4)	None	5x10^{-8} (note 5)	default	default	default

All values are provisional and they need not be met by networks until they are revised (up or down) based on real operational experience – see GENERAL NOTES TO TABLE 1.

GENERAL NOTES TO TABLE 1

The allocations apply to national end-to-end public B-ISDNs composed of national access and transit portions. The allocations are believed to be achievable on long and complex connection portions. The network provider's commitment to the user is to attempt to build network portions achieving each of the applicable allocations. Network portions meeting these allocations are compliant with the performance QoS class definitions in ITU-T Recommendation I.356. The vast majority of national public network connection portions should meet these allocations. When the MP_{INI}s are separated by large geographic distances, the probability of not meeting the applicable portion allocations is increased. For some parameters, performance on shorter and/or less complex connection portions may be significantly better. This will ensure suitable performance for end-to-end domestic connections and will enable the national and transit country objectives specified in ITU-T Recommendation I.356 (§4 and §9) to be met.

Individual network providers may choose to offer performance commitments better than their allocated objectives.

"U" means "unspecified" or "unbounded." When the performance relative to a particular parameter is identified as being "U" T1.511-2003 establishes no allocation for this parameter and any default T1.511-2003 allocation can be ignored. When the objective for a parameter is set to "U," performance with respect to that parameter may, at times, be arbitrarily poor.

Access and transit network portions meeting these allocations fulfill the performance QoS class definitions in I.356.

NOTES

1) It is possible that in the near future, network portions will be able to commit to an order of magnitude improvement in the CER allocations. This subject is for further study.
2) Some network phenomena have been observed that tend to increase the CMR as the cell rate of the virtual connection portion increases. More complete analyses of these phenomena may ultimately suggest a larger CMR allocation for high bit rate connections.
3) The SECBR is sensitive to short interruptions in the cell stream (i.e., 2 to 9 seconds in duration) which will result in many SECBs and may make the SECBR allocation difficult to meet.
4) Applies when there are no more than 2 ATM nodes in the access portion and no more than 1 ATM node in the transit portion with 45 Mbit/s output links, and all other ATM nodes are operating at 150 Mbit/s or higher. 2-pt CDV will generally increase as the transport rates decrease. High bit rate DBR connections may need and may receive less CDV. This is for further study.
5) It is possible that in the near future, networks will be able to commit to a factor of 30 improvement in the CLR allocations for class 1. This subject is for further study.
6) These are worst-case objective values (excluding failure conditions). All output links are operating at 45 Mbit/s or higher. CTD will generally increase as the transport rates decrease. The sum of access and transit values exceeds the ITU-T Recommendation I.356 specification for a terminating country. Compliance with ITU-T Recommendation I.356 is for further study.
7) Users may choose to take advantage of per connection signaling of their CTD needs. Network support of such requests is optional.
8) The end-to-end upper bound on CTD is 360 ms if a satellite is included in the end-to-end connection. If a geo-stationary satellite hop is used within the end-to-end connection, the connection portion containing the geo-stationary satellite is allocated 320 ms CTD.

The allocations in Table 1 apply to access portions and transit portions of public B-ISDNs as defined in clause 4. The allocations are believed to be achievable on complex national connections. These allocations do not account for the performance of private networks or other CEQ performance. CEQ performance is for further study.

The first full row of Table 1 indicates the statistical nature of the performance allocations that appear in the subsequent rows for both the access and transit portions.

The performance allocations for CTD are upper bounds on the underlying mean CTD for the connection portion. Although many individual cells may have transfer delays that exceed this bound, the average CTD for the lifetime of the connection (a statistical estimator of the mean) should normally be less than the CTD bounds.

ITU-T Recommendation Q.2931 enables the user to signal a maximum acceptable CTD. If the user takes advantage of this facility, signaling nodes will deliver an estimate of end-to-end CTD to the called user. Taking account of this CTD estimate, the users may or may not accept the call. The relationship between the signaled CTD values and the network providers' commitment to CTD performance remains to be studied.

The performance allocations for 2-point cell delay variation are upper bounds on the difference between the 10^{-8} and the $1\text{-}10^{-8}$ quantiles of the underlying CTD distribution for the connection portion. Thus, within the connection portion, it should be very difficult to find any two cells with a difference in CTD larger than the CDV bounds. 10^{-8} was chosen because it allows for the proper engineering of delay buildout buffers when the overall CLR allocation is 10^{-8}. The use of other quantiles for 2-point CDV specification is for further study.

The CDV allocations only apply to connection portions that have negotiated appropriately small CDV tolerances in conjunction with their PCRs. A network's CDV allocation does not include the 2-point CDV resulting from actions taken at the network ingress to reduce the amount of 1-point CDV. These network actions are not considered a network induced degradation.

The performance allocations for the cell loss ratios and the cell error ratio are upper bounds on the cell loss and cell error probabilities for the connection portion. Although individual cells will be lost or errored, the underlying probability that any individual cell is lost or is errored during the connection should be less than the bounds presented in this table. When small numbers of cells are observed, it is possible that the computed CLR_{0+1}, CLR_0, and CER will be greater than the bounds for cell loss and cell error probabilities.

The performance allocations for the cell misinsertion rate are upper bounds on the underlying mean rate at which misinserted cell outcomes occur in a connection portion. For a set of connections of sufficient total duration, the computed CMR should be less than the CMR bound.

The performance allocations for the severely errored cell block ratio are an upper bound on the SECB probability in a connection portion. Although individual cell blocks will be severely errored, the underlying probability that any individual cell block is severely errored should be less than the bounds presented in the table. When small numbers of cell blocks are observed, it is possible that the computed SECBR is greater than the bound for SECBR.

5.2 Unbounded (unspecified) performance

For some QoS classes the values for some performance parameters are designated "U." In these cases, T1.511-2003 sets no allocations for a connection portion regarding these parameters and any default T1.511-2003 allocations for these parameters can be ignored. Network operators may unilaterally elect to assure some minimum quality level for the unspecified parameters, but T1.511-2003 will not recommend any such minimum.

NOTE – The word “unspecified” may have a different meaning in standards concerning B-ISDN signaling.

Users of these QoS classes should be aware that the performance of unspecified parameters can, at times, be arbitrarily poor.

5.3 Default values for cell error ratio, cell misinsertion rate, and severely errored cell block ratio

The CER, CMR, and SECBR values cannot be adjusted on a connection-by-connection basis. Therefore the connection portion performance commitments for these parameters do not differ among the QoS classes. The exception is that no commitment will be made to these parameters in the U class.

5.4 Concatenation of QoS values

It is possible to derive the end-to-end performance of a connection when values for its constitute components (i.e., connection portions) are known. For all performance parameters except the CDV, the end-to-end performance may be closely approximated as the sum of the performance allocations for the access and transit portions specified in Table 1. The rule for deriving end-to-end CDV performance from the concatenation of its constituent components is sub-additive and is for further study.

NOTE – When an MP_{INI} is not coincident with a section boundary (see 4.2), calculation of the end-to-end CTD must take into account overlap in the times of occurrence of the relevant exit and entry events at that MP_{INI}.[11]

Examples of calculating concatenated QoS values are provided in A.7.

6 ATM Bringing-Into-Service Criteria for Voice VCs

This clause specifies bringing-into-service test parameters and objectives for ATM virtual connections intended for ITU-T Recommendation G.711, voice applications using QoS class 1. The focus is on testing access network portions. Extensions of these tests to transit portions is for further study. When an ATM virtual connection is supported across the internetwork circuit section connecting the access and transit portions, the operators of these portions will need to cooperate to conduct these tests. Common transport rates are specified.

6.1 ITU-T Recommendation M.2201 Background

ITU-T Recommendation M.2201 gives rules for obtaining bringing-into-service (BIS) and maintenance limits from performance objectives (POs). The major concepts from these rules are:

– That the BIS limit is half the allocated performance;

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[11] Methods for an analogous case are found in T1.504b-1998 (R2002), clause B.1.1.

- That observing performance an order of magnitude worse than the performance objective is deemed unacceptable; and
- That performance is degraded when it is observed to be within 75% of the performance objective.

6.2 National CLR Objectives

From Table 1, the ATM cell loss ratio objectives for class 1 are the same ($5x10^{-8}$) for both access and transit portions.

6.3 BIS Issues

In considering the issues with bringing-into-service of ATM virtual connections – particularly those to be used for voice – the first major issue is what performance parameter(s) to focus on. Cell loss is the major contributor to voice quality degradation in the context of ATM CBR virtual connections. Thus it is important that a cell loss, bringing-into-service measure is needed.

To provide clear consistency with the principles of M.2201 and to have precision with respect to the CLR needed for BIS, as well as to partly account for errored cells, no SECBs are allowed during the BIS test. Thus, the CLR for BIS for access portions for class 1 is $2.5x10^{-8}$.

6.4 Other ATM Performance Parameters

While there are ATM performance parameters other than cell loss ratio, it is important to consider their likely impact on the "cleanness" of ATM virtual connections carrying voice. In the case of the SECBR, it is recognized that any SECBs could have an adverse impact and therefore the SECBR is required by the test to be zero. With regard to cell transfer delay, its impact on voice is similar to that of the transmission latency covered by T1.508[12]. Two-point CDV, CER, CMR still remain. The same mechanisms that produce errored cells would also produce lost cells, and therefore errored cells do not need to be considered separately from lost cells. Additionally, unacceptably large values of CER will be handled by the requirement of no SECBs. CMR is expected to be so low that there is no reason to test for it. With regard to 2-point CDV (1.3 ms for access and 0.7 ms for transit), there is some possibility that this could have an adverse impact on voice services carried by ATM. CDV sufficiently large to adversely affect voice service would also result in lost cells. Therefore, the impact of 2-point CDV on voice service is expected to be secondary to that of CLR. Accordingly, testing of 2-point CDV and the need for such testing is a future work item.

6.5 ATM BIS Test for Virtual Connections Carrying Voice

The intent of this test is to assure a near error-free channel for ITU-T Recommendation G.711 encoded voice using ATM CBR virtual connections. This test applies to CBR virtual connections using class 1 from Table 1, whether or not these connections are PVCs or soft PVCs established by signaling.[13]

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[12] For voice services, partial cell fill may be one way to minimize transport delay.

[13] A soft PVC is a user-to-user connection in which the user-to-network connections are PVCs, but all or part of the cross-network connection is an SVC and does not need to be configured at every hop across the network (as would be the case for a PVC).

To address ongoing regulatory requirements and issues of inter-operability and service uniformity for voice services carried over ATM virtual connections, the following criteria in Table 2 shall be used when bringing such virtual connections into service.

Table 2 - ATM Bringing-Into-Service Criteria for Virtual Connections Carrying Voice

	Short Duration Tests			Long Duration Test (24 hours)
	Lost Cells			Lost Cells
Transport Rate	15 min	30 min	1 hour	24 hour
OC-12	≤ 44	≤ 91	≤ 187	≤ 4568
OC-3	≤ 8	≤ 20	≤ 44	≤ 1135
DS-3	≤ 0	≤ 3	≤ 10	≤ 325
DS-1	≤ 0	≤ 0	≤ 0	≤ 8

NOTE 1 - No SECBs are allowed during these tests. The presence of an SECB will cause the VC to be rejected.

NOTE 2 - These acceptance limits are based on the SPRT tests in Annex B with α=0.05 and β=0.1.

NOTE 3 - A traffic loading of 85% should be placed on the transport under test.

NOTE 4 - The acceptance of the high-speed virtual connection is sufficient for the acceptance of embedded G.711 voice channels.

Informative Annex B provides information on the statistical theory behind the above BIS criteria.

Annex A

(informative)

A Supplemental information on the characterization of national ATM services

This annex provides supplemental (i.e., non-normative) information intended to assist application of ITU-T Recommendation I.356 and T1.511-2003.

A.1 ATM cell transfer outcomes

The inclusion of the tagged cell outcome in T1.511-2003 is not intended to imply a recommendation concerning the use of cell tagging as a policing policy. Instead, the ability to distinguish tagged cell outcomes from other cell transfer outcomes is retained in order to complete the definitions for both CLR_0 and CLR_{0+1}. Tagged cell outcomes are included in the numerator of CLR_0 but are not included in the numerator of CLR_{0+1}.

A.2 Network performance when some cells are non-conforming

ITU-T Recommendation I.356 (§7) does not place any requirements on network operators and, in particular, does not include any requirements for national networks. First, it is a network privilege to choose whether to make any QoS commitments when cells are not conforming with the applicable traffic contract. If a network provider is not interested in making such QoS commitments, that provider may declare a connection non-compliant on receipt of its first non-conforming cell. From that point on, no QoS commitments need be honored and the material of ITU-T Recommendation I.356 (§7) will not be needed. Second, there is no requirement (direct or implied) that a network implement any measurements using the definitions of ITU-T Recommendation I.356 (§7).

However, if a network provider does make QoS commitments when there are non-conforming cells, that provider should be aware that their users may choose to evaluate those commitments using definitions similar to those provided in ITU-T Recommendation I.356 (§7). The specific definitions provided in ITU-T Recommendation I.356 (§7) are maximally generous in determining how many cells a network is allowed to drop (or tag) before increasing the cell loss ratio attributed to the network. Thus, the CLR attributed to networks using the definitions of ITU-T Recommendation I.356 (§7) will be as low as any network CLR computed using alternative definitions -- including those of ITU-T Recommendation I.356 (§6).

A.3 ITU-T Recommendation I.357 guidance on availability

ITU-T Recommendation I.357 presents a definition for availability/unavailability that is being considered for use in the national context (see Annex C).

A.4 Association of QoS classes with ATM transfer capabilities

ITU-T Recommendation I.371 defines ATM transfer capabilities (ATCs). Table 3 of ITU-T Recommendation I.356 recommends that certain ATCs be associated with certain QoS classes. Neither

ITU-T Recommendation I.356 nor T1.511-2003 mandates the use of any particular ATC or QoS class in any particular context.

A.5 References to SDH

References to SDH in ITU-T Recommendation I.356 are replaced with corresponding references to SONET in T1.511-2003.

A.6 Provisional national ATM network portion performance allocations for CLR and CMR

This clause provides information underlying the provisional North American ATM network portion performance allocations for the CLR and CMR performance parameters. Subclause A.6.1 provides information on the general methodology used and A.6.2 provides more detailed information. The provisional national objectives are derived from the end-to-end international objectives and allocation methodology given in ITU-T Recommendation I.356.

A.6.1 General methodology

North American terminating and transit country allocations derived from ITU-T Recommendation I.356 are utilized.

The North American transit network can support international transit country connections (e.g., as part of an end-to-end connection from Europe to a Pacific rim country). Thus as a minimum, the North American transit network portion should meet the ITU-T Recommendation I.356 transit country allocation. This is the basis for the provisional national transit network portion allocations.

Since the North American transit network portion should meet the international transit country allocation, the difference between the terminating and transit country allocations could then be applied to the North American access network portion. This is the basis for the provisional national access portion allocations.

The following Figure illustrates the various network portions:

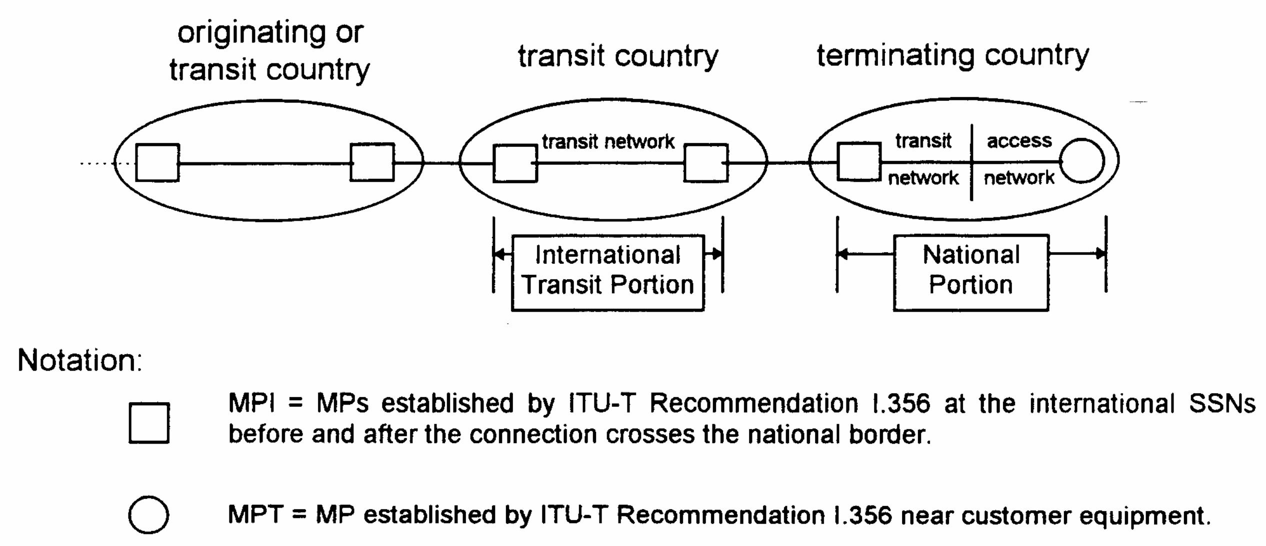

Figure A.1 - Network Portions

A.6.2 Application of general methodology

A.6.2.1 CLR QoS class 1 allocations

A.6.2.1.1 National terminating and transit country allocations for CLR QoS class 1

ITU-T Recommendation I.356 allocations are given as a percent of the end-to-end international objectives.

ITU-T Recommendation I.356 includes the following CLR allocations for QoS class 1:

– The national portion is allocated a 23% block allowance plus 1% per 1000 route kilometers. (This allocation applies to North America as a terminating country.)

– The International Transit Portion (ITP) is allocated a 7% block allowance plus 1% per 1000 route kilometers. (This allocation applies to North America as a transit country.)

A maximum North American end-to-end connection air route distance of 5000 kilometers is assumed. A routing factor or 1.25 applies resulting in 6250 route kilometers. This is rounded up to the nearest 1000 kilometers, and 1% allocated per 1000 kilometers to obtain a 7% distance allocation.

For North America as a terminating country, the national allocation is then 23% (block) plus 7% (route), or 30% of the international end-to-end objective.

For North America as a transit country, the national allocation is then 7% (block) plus 7% (route), or 14% of the international end-to-end objective.

A.6.2.1.2 Provisional national allocations for CLR QoS class 1

The end-to-end international QoS class 1 CLR objective specified in ITU-T Recommendation I.356 is 3×10^{-7}.

The 30% and 14% allocations for North America as a terminating and transit country, respectively, are applied to the above end-to-end international objective to obtain the allocations in the following table:

Table A.1 - CLR allocations for QoS class 1

International connection allocations				Provisional North American national allocations		
International end-to-end	North America as a terminating country	North America as a transit country	(difference) terminating – transit	Transit network portion	Access network portion	End-to-end (see A.7)
(100%) 3×10^{-7}	(30%) 9×10^{-8}	(14%) 4.2×10^{-8}	(16%) 4.8×10^{-8}	5×10^{-8}	5×10^{-8}	1.5×10^{-7}

The North American terminating country allocation is about a factor of two looser than the North American transit country allocation.

As noted in A.6.1, the North American transit network portion should meet the ITU-T Recommendation I.356 transit country allocation. This is the basis for the provisional transit network portion objective. The difference between the terminating and transit country allocations can then be applied to the North American access network portion.

Since the terminating country allocation is about a factor of two looser than the transit country allocation, the North American access network portion may be the same as the North American transit network objective and still meet the ITU-T Recommendation I.356 international terminating country allocation.

A.6.2.2 CLR QoS classes 2 and 3 allocations

A.6.2.2.1 National terminating and transit country allocations for CLR QoS classes 2 and 3

ITU-T Recommendation I.356 allocations are given as a percent of the end-to-end international objectives.

ITU-T Recommendation I.356 includes the following CLR allocations for QoS classes 2 and 3:

– The national portion is allocated a 34.5% block allowance. (This allocation applies to North America as a terminating country.)

– The ITP is allocated a 9% block allowance. (This allocation applies to North America as a transit country.)

The CLR allocation rule for QoS classes 2 and 3 does not make use of the calculated route length.

For North America as a terminating country, the allocation is then 34.5% of the international end-to-end objective.

For North America as a transit country, the allocation is then 9% of the international end-to-end objective.

A.6.2.2.2 Provisional national allocations for CLR QoS classes 2 and 3

The end-to-end international QoS classes 2 and 3 objectives specified in ITU-T Recommendation I.356 are 10^{-5}.

The 34.5% and 9% allocations for North America as a terminating and transit country, respectively, are applied to the above end-to-end international objectives to obtain the allocations in the following table:

Table A.2 - CLR allocations for QoS classes 2 and 3

International connection allocations				**Provisional North American national allocations**		
International end-to-end	North America as a terminating country	North America as a transit country	(difference) terminating – transit	Transit network portion	Access network portion	End-to-end (see A.7)
(100%) 10^{-5}	(34.5%) 3.5×10^{-6}	(9%) 9×10^{-7}	(25.5%) 2.5×10^{-6}	10^{-6}	2.5×10^{-6}	6×10^{-6}

As noted in A.6.1, the North American transit network portion should meet the ITU-T Recommendation I.356 transit country allocation. This is the basis for the provisional North American transit network portion objective. The difference between the terminating and transit country allocations can then be applied to the North American access network portion.

The North American access network allocation is greater than for the North American transit network. This is justified, since switches nearest the source of bursty traffic bear the burden for multiplexing that traffic and should be allowed a larger allocation. This is particularly relevant to classes 2 and 3 where bursty applications are expected to be the norm. This greater allocation to switches nearest the traffic source is consistent with the allocation principles in ITU-T Recommendation I.356.

A.6.2.3 CMR allocations

A.6.2.3.1 National terminating and transit country allocations for CMR

The end-to-end international CMR objective is 1 per day.

ITU-T Recommendation I.356 includes the following CMR allocations:

- The national portion is allocated a CMR of 1 per 72 hours. (This allocation applies to North America as a terminating country.)
- The international portion of the international connection is allocated a CMR of 1 per 72 hours. Allocation to the ITP is for further study.

For North America as a terminating country, the allocation is then a CMR of 1 per 72 hours.

The ITU-T Recommendation I.356 international performance model allows for up to three transit countries. Assuming equal allocation to the three ITPs, this implies that a transit country should support a CMR of 1 per 3 x 72 hours equivalent to 1 per 216 hours.

A.6.2.3.2 Provisional national allocations for CMR

As noted in A.6.1, the North American transit network portion should meet the ITU-T Recommendation I.356 transit country allocation. This is the basis for the proposed North American transit network portion objective. The difference between the terminating and transit country allocations can then be applied to the North American access network portion as shown in the following table:

Table A.3 - Allocations for CMR

International connection allocations				**Provisional North American national allocations** (see note)		
International end-to-end	North America as a terminating country	North America as a transit country	(difference) terminating – transit	Transit network portion	Access network portion	End-to-end (see A.7)
1 per day	1 per 72 hours (3 per 216 hours)	1 per 216 hours implied	2 per 216 hours	1 per 216 hours	2 per 216 hours	5 per 216 hours
NOTE – Some network phenomena have been observed that tend to increase the CMR as the cell rate of the virtual connection increases. More complete analysis of these phenomena may ultimately suggest a larger CMR objective for high bit rate connections.						

A.6.2.4 Provisional national CTD allocations

This subclause provides background information on the provisional worst-case CTD objectives of 10 ms for the access network portion and 45 ms for the transit network portion (see Table 1).

The access and transit network portion allocations are obtained by considering worst-case reference connections for each portion. These reference connections include a number of SONET islands, PDH multiplex/demultiplex pairs, DS1 switches or cross-connects (i.e., synchronous equipment with slip buffers), and ATM switches or cross-connects where traffic is in contention (i.e., where there are queueing delays). The SONET islands portions are based on reference models for DS1 and DS3 transport over SONET for jitter and wander accumulation studies. These reference models are documented in T1.105.03-1994, T1.105.03a-1995, T1.105.03b-1997, and T1.105.09-1996 (R2002). In addition, an identical VC-11 over SDH reference model is included in ITU-T Recommendation G.813.

The case where a satellite is included in the end-to-end connection is not considered in this analysis.

A.6.2.4.1 SONET Islands

The above reference models consider a coast-to-coast DS1 or DS3 transported over SONET. It is assumed the DS1 or DS3 traverses 6 SONET islands in each of 2 LEC networks, 8 SONET islands in each of 2 IEC networks, and 4 SONET islands in a private network (for a total of 32 SONET islands). Each SONET island is assumed to contain as many as 10 pointer processor nodes (the node containing the mapper is an eleventh node; the desynchronizer may be contained in the final pointer processor node). ITU-T Recommendation G.783 requires that AU (i.e., STS) pointer processors have a threshold spacing of at least 4 bytes, and that TU (i.e., VT) pointer processors have a threshold spacing of at least 2 bytes. These minimum values give conservative results for jitter accumulation studies; however, they may give non-conservative results for delay. Note that many vendors build larger buffers, especially for the VT pointer processors. Here, it is assumed both VT and STS pointer processors have threshold spacings of 4 bytes. One byte at the STS-1 rate corresponds to approximately 160 ns; one byte at the VT1.5 rate corresponds to approximately 5 μs. Therefore, a single VT1.5 pointer processor node results in a delay of 20 μs; a single STS pointer processor node results in a delay of 640 ns. Then, delays due to SONET equipment for various scenarios are:

– *LEC Network, 6 STS Islands*:

(6 islands)(10 nodes/island)(640 ns/node) = 38,400 ns = 0.0384 ms

– *LEC Network, 6 VT1.5 Islands*:

(6 islands)(10 nodes/island)(20 μs/node) = 1200 μs = 1.2 ms

– *IEC Network, 8 STS Islands*:

(8 islands)(10 nodes/island)(640 ns/node) = 51,200 ns = 0.0512 ms

– *IEC Network, 8 VT1.5 Islands*:

(8 islands)(10 nodes/island)(20 μs/node) = 1600 μs = 1.6 ms

For the access portion, assume 8 VT1.5 islands; the SONET portion of the delay is 1.6 ms (NOTE - during the discussion, it was indicated that no more than 6 islands should be used; it was also indicated that these would be STS islands when ATM cells are transported). The access portion consists of a single LEC.

For the transit portion, assume 16 VT1.5 islands. This is the allocation for both IECs in the above SONET islands reference model. The resulting SONET portion of the delay is 3.2 ms (NOTE - these are STS islands when ATM cells are transported).

A.6.2.4.2 PDH (e.g., M13) Multiplex/Demultiplex Pairs

Assume one PDH multiplex/demultiplex operation between each SONET island (while this was not formally part of the above reference models, it was assumed in some of the jitter accumulation studies noted above); in addition, assume 1 operation after the final island. Assume each PDH multiplex/demultiplex operation results in a delay corresponding to 2 DS1 frames, or 250 μs. Then the resulting delay is 8(250 μs), or 2 ms, for the access portion, and 16(250 μs), or 4 ms, for the transit portion.

A.6.2.4.3 Switches or Cross-Connects Containing Slip Buffers

For both access and transit portions, assume 4 switches or cross-connects containing slip buffers, each contributing 125 μs of delay. The total delay is 0.5 ms.

A.6.2.4.4 ATM Switches or Cross-Connects Where There is Contention

In accordance with ITU-T Recommendation I.356, a terminating country has 8 nodes and a transit country has 3 nodes. Therefore, the access portion has 8 – 3 = 5 nodes. Each node contributes 300 μs of delay. This results in 0.9 ms for the transit portion and 1.5 ms for the access portion.

A.6.2.4.5 Distance Component

Assume a propagation delay for fiber of 8.4 μs/mile (this corresponds to 1.92×10^8 m/s for the speed of light in fiber). Assume 500 circuit miles in the access portion, and 4000 circuit miles in the transit portion. Then the resulting delays are 4.2 ms for the access portion and 33.6 ms for the transit portion.

A.6.2.4.6 Total CTD

– *For the access portion, the resulting CTD is*:

(1.6 + 2 + 0.5 + 1.5 + 4.2) ms = 9.8 ms

– *For the transit portion, the resulting CTD is*:

(3.2 + 4 + 0.5 + 0.9 + 33.6) ms = 42.2 ms

A.6.2.5 Provisional national CDV allocations

The 2-point CDV allocations from ITU-T Recommendation I.356 is as follows:

– A national portion of the international connection is allowed 1.5 ms of CDV. This allocation applies when there are no more than 3 ATM nodes in the national portion with 34 to 45 Mbit/s output links and all other ATM nodes in the portion are operating at 150 Mbit/s or higher.

– For an ITP take a block allowance of 0.7 ms. This allocation applies when there is no more than one ATM node in the portion with 34 to 45 Mbit/s output links and all other ATM nodes in the portion are operating at 150 Mbit/s or higher.

The terminating country contains an access portion and a transit portion in the North American reference connection. The transit country contains a transit portion in the North American reference connection. Then, assuming (as is assumed in ITU-T Recommendation I.356) that CDVs add as the square root of the sum of the squares (i.e., that the respective queueing delays are uncorrelated), the CDV objective for the access portion is:

$$[(1.5)^2 - (0.7)^2]^{\frac{1}{2}} \text{ ms} = 1.3 \text{ ms}.$$

The end-to-end CDV objective (i.e., end-to-end within North America) is:

$$[(1.3)^2 + (1.3)^2 + (0.7)^2]^{\frac{1}{2}} = 2.0 \text{ ms}.$$

A.6.2.6 Provisional national CER and SECBR allocations

The CER and SECBR allocation methods in ITU-T Recommendation I.356 is a direct application of the ITU-T Recommendation G.826 rules. ITU-T Recommendation G.826 allocation of a percent of the end-to-end international objective include:

- For a national portion, take a block allowance of 17.5% plus 1% per 500 km, if no satellite hop. If there is a geo-stationary satellite hop within the portion, a single 42% block allowance replaces this computation.
- For an ITP, take a block allowance of 2% plus 1% per 500 km, if no satellite hop. If there is a geo-stationary satellite hop within the portion, a single 36% block allowance replaces this computation.

A maximum North American national end-to-end connection air route distance of 5,000 km is assumed. A routing factor of 1.25 applies, resulting in 6,250 route kilometers. This is rounded up to the nearest 500 kilometers and 1% allocated per 500 km to obtain a 13% distance allocation.

As a terminating country, or a national portion, the allocation is then 17.5% (block) plus 13% (route), or 30.5% of the international end-to-end objective. This represents both an access portion and a transit portion in the North American reference connection.

As a transit country, or an ITP, the allocation is then 2% (block) plus 13% (route), or 15% of the international end-to-end objective. This represents a transit portion in the North American reference connection.

The end-to-end international objectives given in ITU-T Recommendation I.356 are for CER a value of 4×10^{-6} and for SECBR a value of 10^{-4}.

Applying the derived allocations of 30.5% and 15% to these international objectives for terminating and transit countries results in the North American international connection allocations. The results of this derivation and the resultant North American objectives for CER and SECBR are shown in the following tables.

Table A.4 - CER allocations

International connection allocations				**Provisional North American national allocations**		
International end-to-end	North America as a terminating country	North America as a transit country	(difference) terminating – transit	Transit network portion	Access network portion	End-to-end
4×10^{-6}	1.22×10^{-6}	6×10^{-7}	6.2×10^{-7}	6×10^{-7}	6×10^{-7}	1.8×10^{-6}

Table A.5 - SECBR allocations

International connection allocations				Provisional North American national allocations		
International end-to-end	North America as a terminating country	North America as a transit country	(difference) terminating – transit	Transit network portion	Access network portion	End-to-end
10^{-4}	3×10^{-5}	1.5×10^{-5}	1.5×10^{-5}	1.5×10^{-5}	1.5×10^{-5}	4.5×10^{-5}

A.7 Example calculations of end-to-end performance values

A.7.1 QoS class 1 CLR

For a national QoS class 1 ATM connection consisting of two access portions and one transit portion, an end-to-end CLR_{0+1} value of 1.5×10^{-7} may be calculated using the methods of 5.4, assuming that the end-to-end value is the linear sum of the portion values. If the access and transit portions exhibit wide variation in their performance distributions, then there is a low probability that all three network portions would simultaneously operate at the worst end of their performance distributions. In that case, statistical concatenation could be used so that the end-to-end national value would be less than the linear sum of the network portion allocations.[14]

A.7.2 QoS class 2 and QoS class 3 CLR

For a national QoS class 2 or class 3 ATM connection consisting of two access portions and one transit portion, an end-to-end CLR_{0+1} and an end-to-end CLR_0 value of 6.0×10^{-6} may be calculated using the methods of 5.4, assuming that the end-to-end objective is the linear sum of the portion values. If the access and transit portions exhibit wide variation in their performance distributions, then there is a low probability that all three network portions would simultaneously operate at the worst end of their performance distributions. In that case, statistical concatenation could be used so that the end-to-end national value would be less than the linear sum of the network portion allocations.[12]

A.7.3 CMR

For a national ATM connection consisting of two access portions and one transit portion, an end-to-end CMR objective of 5 per 216 hours may be calculated using the methods of 5.4, assuming that the end-to-end value is the linear sum of the portion values. If the access and transit portions exhibit wide variation in their performance distributions, then there is a low probability that all three network portions would simultaneously operate at the worst end of their performance distributions. In that case, statistical concatenation could be used so that the end-to-end national value would be less than the linear sum of the network portion allocations.[12]

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14 Statistical concatenation is used in T1.510-1999, T1.514-2001, and T1.517-1995 (R2001).

Annex B

(informative)

B Supplemental information on Derivation of Sequential Test limits for voice Virtual Channels

This annex provides supplemental (i.e., non-normative) information intended to assist application of T1.511-2003. It presents the statistical theory underlying the bringing-into-service test criteria.

B.1 Introduction

ITU-T Recommendation M.2201 states the performance limits for maintenance and BIS that are derived from performance objectives. The relevant points of the Recommendation are:

– The BIS threshold is half the allocated objective;

– Performance that is an order of magnitude worse than objective is unacceptable; and

– The state is declared degraded when the observed performance reaches 75% of the objective.

The dominant metric that affects voice quality is cell loss ratio. When considering the BIS performance objective (BISPO) for voice transmitted over ATM virtual circuits, the "source" of the cell losses affects the numerical value for acceptable quality. Cells that are lost in SECBs, if included in the overall objective, result in increasing the CLR BIS objective. The recommendation at this time is not to allow errored cells or SECBs, and to set the BIS performance threshold at half the allocated objective. For class 0 connections under study, the performance limit for BIS CLR is 2.5×10^{-8}.

Prior to a cutover into service, the circuits must be tested to ensure that they meet the BIS objective. The test duration is the subject of this contribution. The approach taken here to determine sufficient test periods is derived from the method of quality control through acceptance sampling. Essentially, the cell stream that is monitored over a period of time is treated as a production batch in which cells are either good or defective. A good cell is defined as one that is successfully transmitted and received; a defective cell is one that is counted as lost. Then the test procedure is to sample 100% of the batch; based on the observed defects, the batch is either accepted or is rejected. The number of allowable defects is determined by choosing the producer's risk and consumer's risk for accepting or rejecting batches that are at some selected level of quality. This sampling procedure is equivalent to hypothesis testing using the likelihood ratio in which both the Type I and Type II errors are controlled. Two sampling methods are discussed and compared. First, fixed duration tests are analyzed, followed by the variable duration testing procedure, sequential probability ratio test (SPRT).

B.2 Fixed Duration Single Sampling Plan

The goal of this approach is to determine a single sampling plan that simultaneously satisfies a producer’s risk target (equivalent to specifying a Type I error) for a given acceptable quality level (equivalent to the BIS objective cell loss ratio) and a consumer’s risk target (equivalent to a Type II error) for a given probability of acceptance (equivalent to the objective cell loss ratio). The producer’s risk point (p_1, $1-\alpha$) and the consumer’s risk point (p_2, β) jointly determine a unique single sampling plan. The appropriate probability model for the cell stream in which each cell is either good or defective is a binomial; because of the very small probability of a defect and the large sample size, the Poisson distribution is an accurate approximation for the calculations.

The attached worksheet extract labeled Single Sample (Table B.1) shows the calculations to derive the two parameters for sampling: n, the sample size, and c, the acceptance number or maximum allowable number of defects in the sample. The test duration is derived from the sample size as a function of the line rate and the cell size.

For this single sampling plan, the producer's risk point was set at (p_1, 1-α) = (2.5 x 10^{-8}, 0.05), and the consumer's risk point was fixed at (p_2, β) = (5 x 10^{-8}, 0.1). The choice of p_1 is the BIS cell loss ratio objective, which is half of p_2, the service quality cell loss ratio for voice. The required times to execute the tests are reasonable for DS-3, OC-3, and OC-12, but are excessive for DS1 and DS0. At these lower speeds, an alternative approach -- sequential testing -- can provide accurate results while reducing the expected sample size or test duration.

Table B.1 - Single Sample

Sample Size	Acceptance Number	Line Rate	Circuit Level	Test Duration		
n	c	R (bits/sec)		T (sec)	T (min)	T (hr)
4.98E+08	18	6.40E+04	DS0	3297130	54952.17	915.8694
	18	1.54E+06	DS1	136669	2277.81	37.9635
	18	4.47E+07	DS3	4717	78.61	1.3103
	18	1.55E+08	OC-3	1361	22.69	0.3782
	18	6.22E+08	OC-12	339	5.65	0.0942

Parameters: p_α = 2.5 x 10^{-8}, p_β = 5 x 10^{-8}, α = 0.05, β = 0.1

B.3 Sequential Sampling Plan

Sequential sampling plans, derived from the Wald SPRT, may be used to minimize the required sample size while maintaining the desired quality protection. For given parameters α, β, p_1, and p_2 (as described in the fixed duration single sampling plan), the sequential plan defines thresholds of defect counts relative to the number of items sampled, which determines when the test can be halted either because the sample can be accepted with confidence at the producer's risk level, or rejected with confidence at the consumer's risk level. If the defect count does not satisfy the threshold for acceptance or rejection, the test continues until a threshold is reached, or until the maximum stipulated sample size has been inspected. In general, the sequential test arrives at a decision more quickly than the fixed size sampling method, although it is possible that it may require the same sample size and test duration as the single sample plan cited above.

The form of the probability ratio test is:

$$\frac{(p_1)^d\,(1-p_1)^{n-d}}{(p_2)^d\,(1-p_2)^{n-d}}$$

The plan is defined by the equations of the rejection line, $d_2 = sn + h_2$, and the acceptance line $d_1 = sn - h_1$, where d is the count of defects in the sample, and n is the number of items sampled. The slope of the lines, s, depends on p_1 and p_2; the intercepts, h_1 and h_2, depend on p_1, p_2, α, and β. The functional dependencies are shown below:

$$g_1 = \log (p_2/p_1)$$

$$g_2 = \log (1-p_1/1-p_2)$$

$$a = \log (^{1-\beta}/ \alpha)$$

$$b = \log (^{1-\alpha}/ \beta)$$

$$h_1 = b/(g_1 + g_2)$$

$$h_2 = a/(g_1 + g_2)$$

$$s = g_2/(g_1 + g_2)$$

The worksheet extraction labeled SPRT (Table B.2) shows numerical results for various combinations of test duration (T), α, β, and line rates. The quality levels were fixed at $p_1 = 2.5 \times 10^{-8}$, corresponding to the BISPO for cell loss ratio, and $p_2 = 5 \times 10^{-8}$, the cell loss ratio objective for an operating circuit. Negative values indicate that the sample size is not large enough to reach a decision, and the test must continue.

Table B.2 - Worksheet extraction SPRT

α	β	g1	g2	a	b	h1	h2	s
0.05	0.2	0.30103	1.08574E-08	1.20412	0.676694	2.247927	7.467453	3.60674E-08
0.05	0.1	0.30103	1.08574E-08	1.255273	0.977724	3.247927	10.78938	3.60674E-08
0.1	0.2	0.30103	1.08574E-08	0.90309	0.653213	2.169925	7.208334	3.60674E-08
0.1	0.1	0.30103	1.08574E-08	0.954243	0.954243	3.169925	10.53026	3.60674E-08

Test Duration T=15 min

	α=0.05 β=0.2		α=0.05 β=0.1		α=0.1 β=0.2		α=0.1 β=0.1		
sample size n	accept	reject	accept	reject	accept	reject	accept	reject	**Line Rate**
135850	-2.24303	7.472353	-3.243027677	10.79428	-2.16503	7.213234	-3.16503	10.53516188	DS-0
3277359	-2.12972	7.585659	-3.129721674	10.90759	-2.05172	7.32654	-3.05172	10.64846788	DS-1
94958491	1.176976	10.89236	0.176976215	14.21428	1.254979	10.63324	0.254979	13.95516577	DS-3
329009434	9.61858	19.33396	8.618579663	22.65589	9.696582	19.07484	8.696582	22.39676922	OC-3
1320283019	45.37122	55.0866	44.37121706	58.40853	45.44922	54.82748	44.44922	58.14940662	OC-12

Test Duration T=30 min

	α=0.05 β=0.2		α=0.05 β=0.1		α=0.1 β=0.2		α=0.1 β=0.1		
sample size n	accept	reject	accept	reject	accept	reject	accept	reject	**Line Rate**
271699	-2.23813	7.477252	-3.238127958	10.79918	-2.16013	7.218134	-3.16013	10.5400616	DS-0
6554717	-2.01152	7.703864	-3.011515952	11.02579	-1.93351	7.444746	-2.93351	10.76667361	DS-1
189916982	4.60188	14.31726	3.601879827	17.63919	4.679882	14.05814	3.679882	17.38006938	DS-3
658018868	21.48509	31.20047	20.48508672	34.52239	21.56309	30.94135	20.56309	34.26327628	OC-3
2640566038	92.99036	102.7057	91.99036152	106.0277	93.06836	102.4466	92.06836	105.7685511	OC-12

Test Duration T=60 min

	α=0.05 β=0.2		α=0.05 β=0.1		α=0.1 β=0.2		α=0.1 β=0.1		
sample size n	accept	reject	accept	reject	accept	reject	accept	reject	**Line Rate**
543397	-2.22833	7.487052	-3.22832852	10.80898	-2.15033	7.227933	-3.15033	10.54986104	DS-0
13109434	-1.7751	7.940276	-2.775104509	11.2622	-1.6971	7.681157	-2.6971	11.00308505	DS-1
379833963	11.45169	21.16707	10.45168705	24.489	11.52969	20.90795	10.52969	24.22987661	DS-3
1316037736	45.2181	54.93348	44.21810084	58.25541	45.2961	54.67436	44.2961	57.9962904	OC-3
5281132075	188.2287	197.944	187.2286504	201.266	188.3067	197.6849	187.3067	201.00684	OC-12

Test Duration T=24 hr

	α=0.05 β=0.2		α=0.05 β=0.1		α=0.1 β=0.2		α=0.1 β=0.1		
sample size n	accept	reject	accept	reject	accept	reject	accept	reject	**Line Rate**
13041510	-1.77755	7.937826	-2.777554368	11.25975	-1.69955	7.678707	-2.69955	11.00063519	DS-0
314626416	9.099822	18.8152	8.099821909	22.13713	9.177824	18.55608	8.177824	21.87801147	DS-1
9116015094	326.5428	336.2582	325.5428193	339.5801	326.6208	335.9991	325.6208	339.3210089	DS-3
31584905660	1136.937	1146.652	1135.93675	1149.974	1137.015	1146.393	1136.015	1149.71494	OC-3
1.26747E+11	4569.19	4578.905	4568.18994	4582.227	4569.268	4578.646	4568.268	4581.96813	OC-12

NOTES

1) p1 = 2.5E-08
2) p2 = 5.0E-08

B.4 Discussion of Results

At DS1 line rates and higher, the SPRT reduces the test duration compared with a single, fixed duration sampling plan with comparable levels of consumer and producer risk points. However, for DS0 rates, even a 24 hour sequential test is insufficient to reach conclusive quality results. One cause that necessitates a large sample size is the ratio of stipulated values of product quality (p_1) to defectives (p_2).

Annex C

(informative)

C Bibliography

C.1 American National Standards (Telecommunications) and Committee T1 Technical Reports (TRs)

T1.105.03-1994*, Synchronous Optical Network (SONET) – Jitter at network interfaces.*[3]

T1.105.03a-1995*, Synchronous Optical Network (SONET) – Jitter at network interfaces – DS1 supplement.*[3]

T1.105.03b-1997*, Synchronous Optical Network (SONET) – Jitter at network interfaces – DS3 wander supplement.*[3]

T1.105.09-1996 (R2002)*, Synchronous Optical Network (SONET) – Network element timing and synchronization.*[3]

T1.504-1998 (R2002), *Packet-switched data communication service – Performance objectives.*[3]

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T1.508-1998, *Loss Plan for Evolving Digital Networks*.[3]

T1.510-1999, *Network performance parameters for dedicated digital services – Specifications*.[3]

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T1.517-1995 (R2001), *Performance parameters and objectives for Integrated Services Digital Network (ISDN)*.[3]

T1.629-1999, *Broadband ISDN – ATM adaptation layer 3/4 common part functions and specification*.[3]

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T1.TR.51-1996, *Changes in the Network Access Model*.[3]

C.2 ITU-T Recommendations

ITU-T Recommendation G.114, *One-way transmission time.* [5]

ITU-T Recommendation G.783, *Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks.* [5]

ITU-T Recommendation G.813*, Timing characteristics of SDH equipment clocks (SEC).* [5]

ITU-T Recommendation G.826, *Error performance parameters and objectives for international constant bit rate digital paths at or above the primary rate.* [5]

ITU-T Recommendation I.113, *Vocabulary of terms for broadband aspects of ISDN.* [5]

ITU-T Recommendation I.150, *B-ISDN ATM functional characteristics.* [5]

ITU-T Recommendation I.311, *B-ISDN general network aspects.* [5]

ITU-T Recommendation I.321, *B-ISDN protocol reference model and its application.* [5]

ITU-T Recommendation I.350, *General aspects of quality of service and network performance in digital networks, including ISDNs.* [5]

ITU-T Recommendation I.351, *Relationships among ISDN performance recommendations.* [5]

ITU-T Recommendation I.357, *B-ISDN semi-permanent connection availability.* [5]

ITU-T Recommendation I.363, *B-ISDN ATM adaptation layer (AAL) layer specification.* [5]

ITU-T Recommendation I.413, *B-ISDN user-network interface with broadband capabilities.* [5]

ITU-T Recommendation I.610, *B-ISDN operations and maintenance principles and functions.* [5]

ITU-T Recommendation I.1195, *B-ISDN ATM layer specification.* [5]

ITU-T Recommendation O.191, *Equipment to assess ATM layer cell transfer performance.* [5]

ITU-T Recommendation Q.2761, *B-ISDN. Function description of the B-ISDN user part (B-ISUP) of signalling system no. 7.* [5]

ITU-T Recommendation Q.2762, *B-ISDN. General functions of messages and signals of the B-ISDN user part (B-ISUP) of signalling system no. 7.* [5]

ITU-T Recommendation Q.2764, *B-ISDN. Signaling system no. 7 B-ISDN user part (B-ISUP). Basic call procedures.* [5]

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ITU-T Recommendation Q.2962, *B-ISDN. Digital subscriber signalling system no. 2 (DSS 2). Connection characteristics negotiation feature during call/connection establishment phase.* [5]

ITU-T Recommendation Q.2963, *B-ISDN. Digital subscriber signalling system no. 2 (DSS 2). Connection characteristics modification feature.* [5]

C.3 ATM Forum documents

The following ATM Forum-approved documents provide a related perspective on ATM performance issues. These documents are referenced for information.

ATM Forum af-bici-0013.003*, Broadband-Inter-Carrier-Interconnect Specification 2.0 (Integrated Specification).*[15]

ATM Forum af-pnni-0055.000*, Private-Network-to-Network Interface Specification V1.0.*[15]

ATM Forum af-pnni-0066.000*, Private-Network-to-Network Interface Specification V1.0 Addendum.*[15]

ATM Forum af-pnni-0075.000*, Private-Network-to-Network Interface Specification – ABR Addendum.*[15]

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[15] Available from ATM Forum, 2570 West El Camino Real, Suite 304, Mountain View, CA 94040-1313.