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SERIES M: TMN AND NETWORK MAINTENANCE: INTERNATIONAL TRANSMISSION SYSTEMS, TELEPHONE CIRCUITS, TELEGRAPHY, FACSIMILE AND LEASED CIRCUITS

International transport network

Performance limits for bringing-into-service and maintenance of international multi-operator PDH paths and connections

ITU-T Recommendation M.2100

ITU-T M-SERIES RECOMMENDATIONS

TMN AND NETWORK MAINTENANCE: INTERNATIONAL TRANSMISSION SYSTEMS, TELEPHONE CIRCUITS, TELEGRAPHY, FACSIMILE AND LEASED CIRCUITS

For further details, please refer to the list of ITU-T Recommendations.

ITU-T Recommendation M.2100

Performance limits for bringing-into-service and maintenance of international multi-operator PDH paths and connections

Summary

This Recommendation provides limits for bringing-into-service and maintenance of international multi-operator PDH paths which operate at or above the primary rate, and connections which operate below the primary rate. Error, timing and availability performance are considered. A method for deriving ES and SES from in-service measurement is given for all hierarchical levels. Sections are not covered by this Recommendation. BIS limits and maintenance procedures for radio sections are described in the relevant ITU-R Recommendations.

Source

ITU-T Recommendation M.2100 (2003) was approved by ITU-T Study Group 4 (2001-2004) under the ITU-T Recommendation A.8 procedure on 13 April 2003.

Keywords

Availability, bringing-into-service (BIS), digital path, digital connection, error performance parameter, errored second (ES), maintenance limit, performance allocation, performance objective (PO), severely errored second (SES), unavailability.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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ITU-T Recommendation M.2100

Performance limits for bringing-into-service and maintenance of international multi-operator PDH paths and connections

1 Scope

The purpose of this Recommendation is to provide limits for bringing-into-service and limits for maintenance of international multi-operator digital PDH paths which operate at or above the primary rate, and connections which operate below the primary rate, in order to achieve the performance objectives given for a multiservice environment. These objectives include error performance (ITU-T Recs G.821 and G.826), timing performance (ITU-T Rec. G.822) and availability. This Recommendation defines the parameters and their associated objectives in order to respect the principles given in ITU-T Recs M.20, M.32 and M.34.

"International multi-operator" in this Recommendation refers to PDH paths and connections which cross international boundaries with a change in jurisdictional responsibility.

The methods and procedures for applying these limits are described in ITU-T Rec. M.2110 for the bringing-into-service procedures and in ITU-T Rec. M.2120 for the maintenance procedures.

This Recommendation uses certain principles which are the basis of the maintenance of a digital network:

– it is desirable to do in-service, continuous measurements. In some cases (e.g., for bringing-into service), out-of-service measurements may be necessary;
– a single set of parameters must be used for maintenance of every level of the hierarchy (this principle does not apply to limits);
– error performance limits of transmission systems are dependent on the medium used; however, due to the many possible network structures, error performance limits on paths are independent of the medium.

Since the performance limits are intended to satisfy the needs of the evolving digital network, it must be recognized that such limits might not be achieved by all of today's digital equipment and systems.

Currently, this Recommendation covers the error performance limits for paths at every level of the PDH hierarchy and in-service parameter evaluation criteria up to the quarternary layer and, for connections below the primary rate, down to 64 kbit/s. Sections are not covered.

By bilateral agreement, ITU-R Rec. F.1330-1 may be used in conjunction with this Recommendation for radio-relay systems where applicable.

Throughout this Recommendation the terms "path" and "connections" should be understood as digital.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

– ITU-R Recommendation F.1330-1 (1999), *Performance limits for bringing-into-service of the parts of international plesiochronous digital hierarchy and synchronous digital hierarchy paths and sections implemented by digital radio-relay systems*.
– ITU-T Recommendation G.703 (2001), *Physical/electrical characteristics of hierarchical digital interfaces*.
– ITU-T Recommendation G.704 (1998), *Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels*.
– ITU-T Recommendation G.706 (1991), *Frame alignment and cyclic redundancy check (CRC) procedures relating to basic frame structures defined in Recommendation G.704*.
– ITU-T Recommendation G.724 (1988), *Characteristics of a 48-channel low bit rate encoding primary multiplex operating at 1544 kbit/s*.
– ITU-T Recommendation G.732 (1988), *Characteristics of primary PCM multiplex equipment operating at 2048 kbit/s*.
– ITU-T Recommendation G.733 (1988), *Characteristics of primary PCM multiplex equipment operating at 1544 kbit/s*.
– ITU-T Recommendation G.734 (1988), *Characteristics of synchronous digital multiplex equipment operating at 1544 kbit/s.*
– ITU-T Recommendation G.735 (1988), *Characteristics of primary PCM multiplex equipment operating at 2048 kbit/s and offering synchronous digital access at 384 kbit/s and/or 64 kbit/s*.
– ITU-T Recommendation G.736 (1993), *Characteristics of a synchronous digital multiplex equipment operating at 2048 kbit/s*.
– ITU-T Recommendation G.737 (1988), *Characteristics of an external access equipment operating at 2048 kbit/s offering synchronous digital access at 384 kbit/s and/or 64 kbit/s*.
– ITU-T Recommendation G.738 (1988), *Characteristics of primary PCM multiplex equipment operating at 2048 kbit/s and offering synchronous digital access at 320 kbit/s and/or 64 kbit/s*.
– ITU-T Recommendation G.739 (1988), *Characteristics of an external access equipment operating at 2048 kbit/s offering synchronous digital access at 320 kbit/s and/or 64 kbit/s*.
– ITU-T Recommendation G.742 (1988), *Second order digital multiplex equipment operating at 8448 kbit/s and using positive justification*.
– ITU-T Recommendation G.743 (1988), *Second order digital multiplex equipment operating at 6312 kbit/s and using positive justification*.
– ITU-T Recommendation G.745 (1988), *Second order digital multiplex equipment operating at 8448 kbit/s and using positive/zero/negative justification*.
– ITU-T Recommendation G.747 (1988), *Second order digital multiplex equipment operating at 6312 kbit/s and multiplexing three tributaries at 2048 kbit/s*.
– ITU-T Recommendation G.751 (1988), *Digital multiplex equipments operating at the third order bit rate of 34 368 kbit/s and the fourth order bit rate of 139 264 kbit/s and using positive justification*.
– ITU-T Recommendation G.752 (1988), *Characteristics of digital multiplex equipments based on a second order bit rate of 6312 kbit/s and using positive justification*.
– ITU-T Recommendation G.753 (1988), *Third order digital multiplex equipment operating at 34 368 kbit/s and using positive/zero/negative justification*.

- ITU-T Recommendation G.754 (1988), *Fourth order digital multiplex equipment operating at 139 264 kbit/s and using positive/zero/negative justification*.
- ITU-T Recommendation G.755 (1988), *Digital multiplex equipment operating at 139 264 kbit/s and multiplexing three tributaries at 44 736 kbit/s*.
- ITU-T Recommendation G.761 (1988), *General characteristics of a 60-channel transcoder equipment*.
- ITU-T Recommendation G.762 (1988), *General characteristics of a 48-channel transcoder equipment*.
- ITU-T Recommendation G.775 (1998), *Loss of Signal (LOS) and Alarm Indication Signal (AIS) and Remote Defect Indication (RDI) defect detection and clearance criteria for PDH signals*.
- ITU-T Recommendation G.793 (1988), *Characteristics of 60-channel transmultiplexing equipments*.
- ITU-T Recommendation G.794 (1988), *Characteristics of a 24-channel transmultiplexing equipment*.
- ITU-T Recommendation G.821 (2002), *Error performance of an international digital connection operating at a bit rate below the primary rate and forming part of an Integrated Services Digital Network*.
- ITU-T Recommendation G.822 (1988), *Controlled slip rate objectives on an international digital connection*.
- ITU-T Recommendation G.823 (2000), *The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy*.
- ITU-T Recommendation G.824 (2000), *The control of jitter and wander within digital networks which are based on the 1544 kbit/s hierarchy*.
- ITU-T Recommendation G.826 (2002), *End-to-end error performance parameters and objectives for international, constant bit-rate digital paths and connections*.
- ITU-T Recommendation H.221 (1999), *Frame structure for a 64 kbit/s to 1920 kbit/s channel in audiovisual teleservices*.
- ITU-T Recommendation M.20 (1992), *Maintenance philosophy for telecommunication networks*.
- ITU-T Recommendation M.32 (1988), *Principles for using alarm information for maintenance of international transmission systems and equipment*.
- ITU-T Recommendation M.34 (1988), *Performance monitoring on international transmission systems and equipment*.
- ITU-T Recommendation M.35 (1988), *Principles concerning line-up and maintenance limits*.
- ITU-T Recommendation M.60 (1993), *Maintenance terminology and definitions*.
- ITU-T Recommendation M.2110 (2002), *Bringing into service international multi-operator paths, sections and transmission systems*.
- ITU-T Recommendation M.2120 (2002), *International multi-operator paths, sections and transmission systems fault detection and localization procedures*.

3 Terms and definitions

General terms and definitions related to this Recommendation are provided in ITU-T Rec. M.60. In addition, this Recommendation defines the following terms:

3.1 Performance Objective (PO): Performance objective for the international portion of the hypothetical reference path (see Figure 3/G.826) and the hypothetical reference connection (see Figure 1/G.821).

3.2 Allocated Performance Objective (APO): Performance objective for a real path or connection calculated according to the allocation rules.

3.3 Bringing-Into-Service Performance Objective (BISPO): Bringing-into-service performance objective for a real path or connection calculated from its APO.

3.4 international portion: An international digital path can be subdivided into two national portions and one international portion. The boundary between these portions is defined to be at an International Gateway (IG), which corresponds to:

– an International Switching Centre (ISC), on the international side, for 64 kbit/s paths between switches (IG = ISC = Path End Point (PEP);
– an International Digital Transmission Centre (IDTC) for paths at 2 Mbit/s and above (IG = IDTC = PEP), carrying lower order paths providing paths between ISCs or leased lines.

When the 2 Mbit/s paths are terminated inside an ISC (ISC = PEP), IG is located at the IDTC associated with the ISC. No national portion has to be considered since IDTC and ISC are situated in the same geographical area.

The national portion is outside the scope of this Recommendation.

3.5 international boundary and border crossing points: The International Boundary, the point at which control transfers from one international operator to the next international operator, normally exists within the Inter Country Path Core Element (ICPCE). Generally, this would be half-way along a submarine cable or terrestrial border crossing ICPCE. The Border Crossing Point may coincide with the International Boundary (for example, for a terrestrial border crossing ICPCE) or, in the case of a submarine cable (for example), there would be two border crossings, corresponding to the coastline of the operator's country, which would not coincide with the International Boundary.

3.6 Path Core Element (PCE): An international digital path has been partitioned in geographical terms for the purpose of allocating the PO. These partitions have been titled Path Core Elements.

Two types of PCEs are used:

– an International Path Core Element (IPCE) is between an IG and a frontier station (FS) in a terminating country, or between frontier stations in a transit country;
– an ICPCE is between the adjacent frontier stations of the two countries involved. The ICPCE corresponds to the highest order digital path carried on a digital transmission system linking the two countries. An ICPCE may be transported on a terrestrial, satellite or undersea cable transmission system.

There are two cases where a country may not contain an IPCE:

– depending on the geographical situation and network topology, the IG may coincide with the FS in a terminating country;
– the path uses only one FS in a transit country.

4 Abbreviations

This Recommendation uses the following abbreviations:

AIS	Alarm Indication Signal
APO	Allocated Performance Objective
BER	Bit Error Ratio
BIS	Bringing-Into-Service
BISPO	Bringing-Into-Service Performance Objective
CRC	Cyclic Redundancy Check
DPL	Degraded Performance Level
ES	Errored Second
FAS	Frame Alignment Signal
FS	Frontier Station
IB	International Boundary
ICPCE	Inter-Country Path Core Element
IDTC	International Digital Transmission Centre
IG	International Gateway
IPCE	International Path Core Element
ISC	International Switching Centre
ISDN	Integrated Services Digital Network
LOF	Loss Of Frame
LOS	Loss Of Signal
PCE	Path Core Element
PDH	Plesiochronous Digital Hierarchy
PEP	Path End Point
PO	Performance Objective
PRBS	Pseudo-Random Binary Sequence
RDI	Remote Defect Indication
SES	Severely Errored Second
TMN	Telecommunications Management Network
TP	Test Period
UPL	Unacceptable Performance Level

5 Reference models

5.1 Hypothetical reference performance models for international 64 kbit/s connections

Two ITU-T Recommendations deal with performance of international digital connections operating below the primary rate:

– ITU-T Rec. G.821 for connections using equipment designed before the adoption of ITU-T Rec. G.826 in November 2002;

– ITU-T Rec. G.826 for the other connections.

So, two reference models are defined, one for connections designed to ITU-T Rec. G.821 and another one for connections designed to ITU-T Rec. G.826 (2002).

5.1.1 Connections using equipment designed before the adoption of ITU-T Rec. G.826 (2002)

The physical relationship between international paths of the primary rate network layer and connections in the 64 kbit/s network layer is illustrated in Figure 1.

Key points to note in Figure 1 are:

a) Paths of the primary rate network layer can serve either:
   - peer-layer clients, e.g., an H12 channel in the case of 2048 kbit/s paths; or
   - lower order clients, e.g., 64 kbits/s section of a path in the 64 kbit/s network layer.

b) The international portion of the 64 kbit/s connection is given 40% of the end-to-end error PO.

c) Some examples of international primary rate paths are given in Annex A. These examples also illustrate the breakdown of the international primary rate path into PCEs; the PCE APOs are given in Table 2b.

d) Simple addition of the PCE APOs is assumed when determining the end-to-end APO (i.e., between primary rate – PEPs). Moreover, simple addition of tandemed international primary rate path APOs is assumed when considering the APO offered to the section of the 64 kbit/s network layer.

e) Sensible engineering planning is required to ensure that tandemed international primary rate paths respect the 40% allocation to 64 kbit/s connections.

5.1.2 Connections using equipment designed after the adoption of ITU-T Rec. G.826 (2002)

The physical relationship between connections and higher order paths is illustrated in Figure 2a. Key points to note in Figure 2a:

a) Allocation of the end-to-end connection is specified in ITU-T Rec. G.826.

b) The international portion of connections is given a maximum of 63% of the end-to-end PO.

5.2 Hypothetical reference performance model for international primary and higher order paths

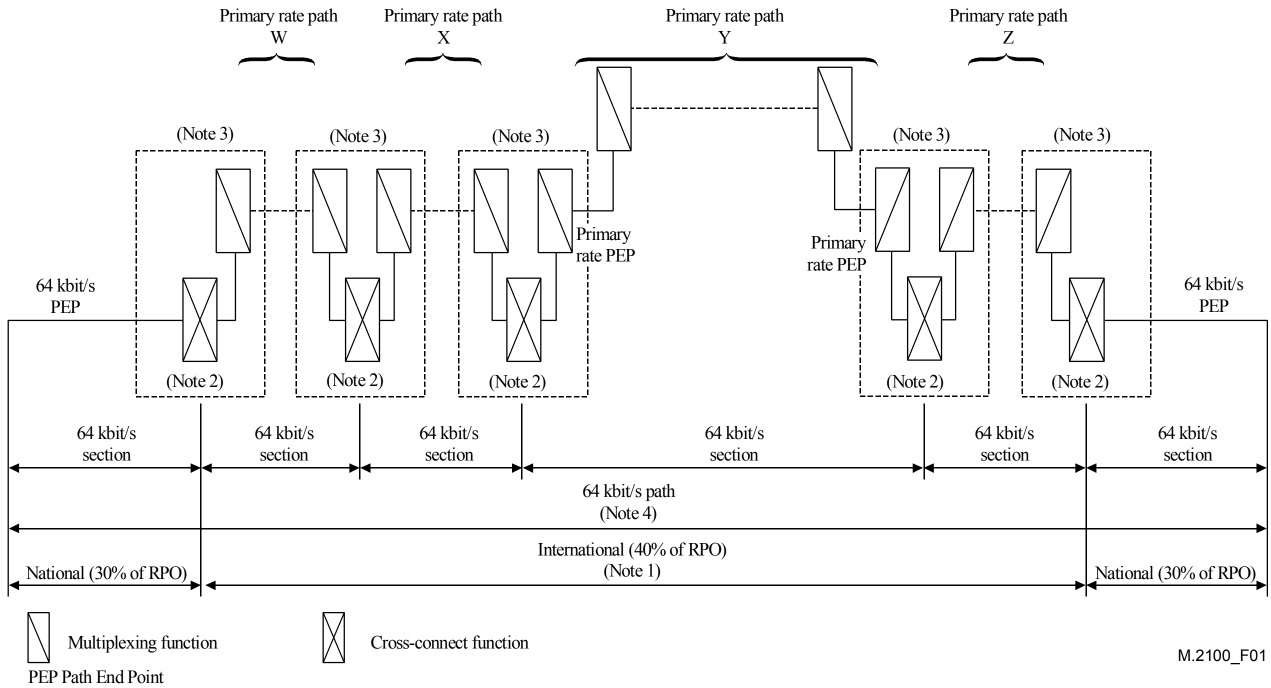
The physical relationship between international primary and higher order paths is illustrated in Figure 2b. Key points to note in Figure 2b are:

a) Allocation of the end-to-end path is specified in ITU-T Rec. G.826.

b) According to ITU-T Rec. G.826, the international portion of primary and higher order paths are given a maximum 63% of the end-to-end error PO.

c) Sensible engineering planning is required to ensure that international "n" Mbit/s paths in tandem, above or equal to the primary rate respect the 63% allocation.

d) Some examples of primary and higher order international paths are provided in Annex A.



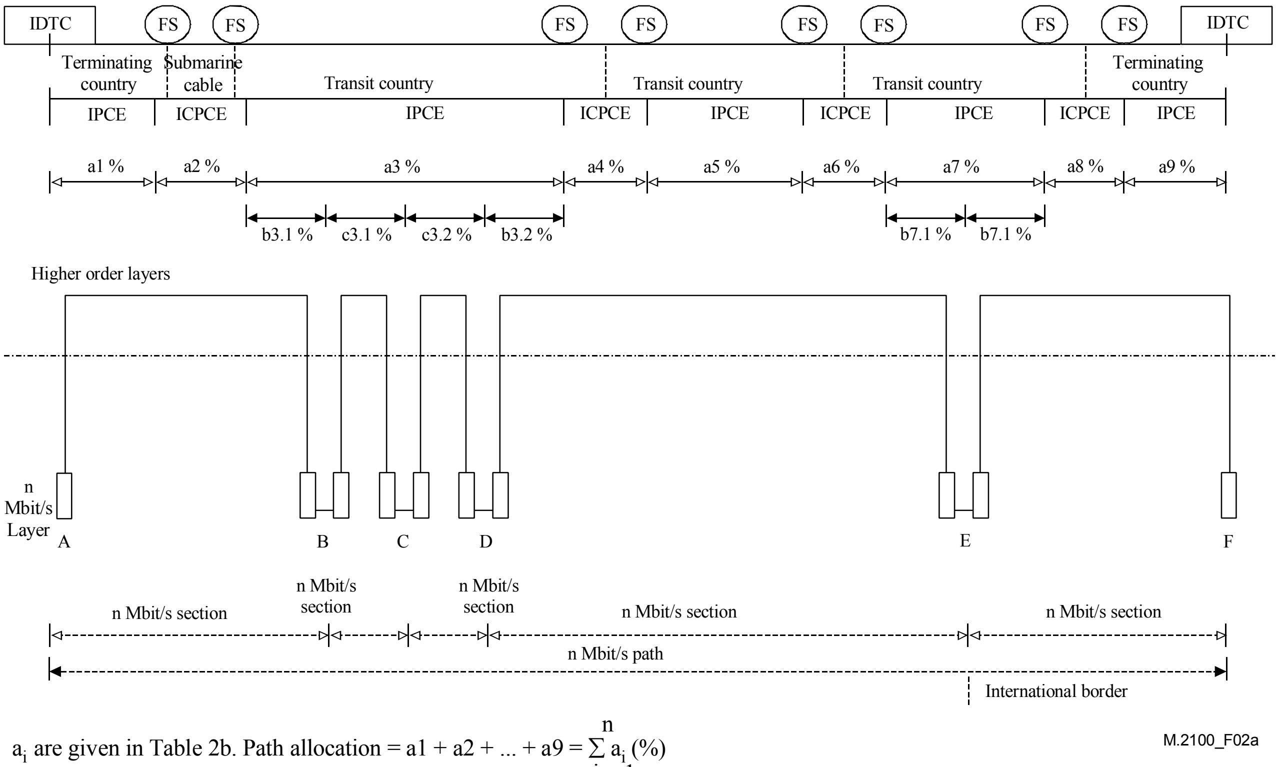
NOTE 1 – The international portion of 64 kbit/s path may be made up of up to 4 tandem primary rate paths W, X, Y and Z, where $W + X + Y + Z \leq 40\%$ of the total RPO.

NOTE 2 – For a 64 kbit/s switched connection, this point has historically been referred to as an (International Switching Centre). For other network layers, the node of the network (e.g., digital distribution frames) is defined to exist at the International Digital Transmission Centre (IDTC).

NOTE 3 – The primary rate PEPs logically terminate the primary rate transmission network layer. Physically, however, it might reside in a 64 kbit/s node, e.g., an International Switching Centre for International 64 kbit/s switched ISDN path.

NOTE 4 – In the case of a 64 kbit/s ISDN path, further information on the partitioning of quality classes (e.g., high grade, medium grade and low grade) is given in Figure 1/G.821 [1].

Figure 1/M.2100 – HRP model for international primary rate path and 64 kbit/s path



a_i are given in Table 2b. Path allocation = a1 + a2 + ... + a9 = $\sum_{i=1}^{n} a_i$ (%)

b_i and c_i values are the responsibility of the national network operators for country i with the following constraints: $b_i \times n + c_i \times m \le a_i$ for each PCE; where n = 1, 2, ... , and m = 1, 2, ... , etc.

c_i values must be communicated to each control station.

Figure 2a/M.2100 – Example of apportionment for an international n Mbit/s path, where n = 1.5, 2, 6, 8, ... , 140

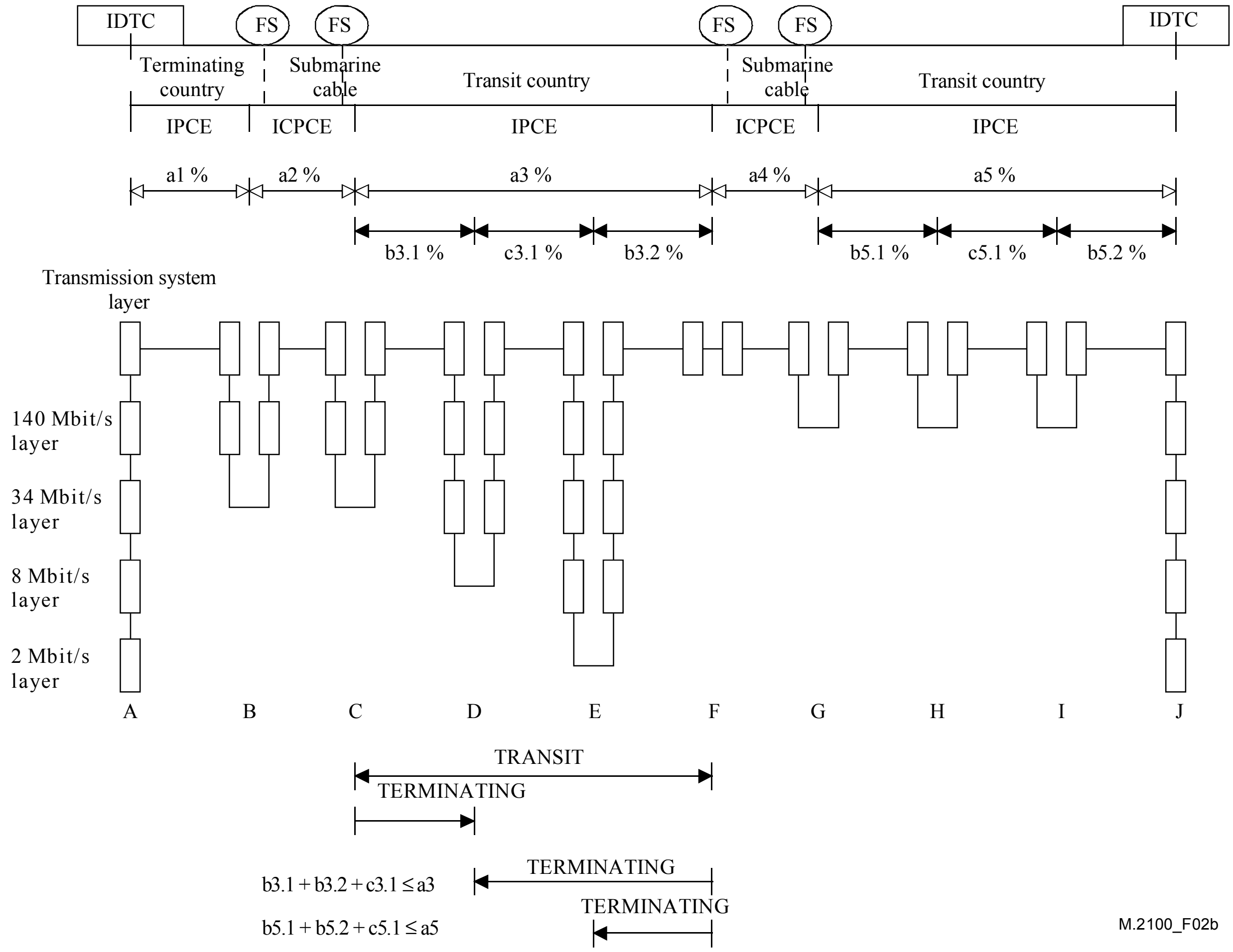


Figure 2b/M.2100 – Example of apportionment for a primary rate path showing the relationship with the higher bit rate paths which support it

6 Performance objectives

In this Recommendation, ES and SES events are dealt with. Both performance events are considered essential for BIS and maintenance.

6.1 Connections operating below the primary rate

There are two types of connections, those using equipment designed before the approval of revised ITU-T Rec. G.826 (2002) and those using equipments designed according to ITU-T Rec. G.826 (2002).

6.1.1 Connections using equipment designed before the adoption of revised ITU-T Rec. G.826

The ES performance objective (PO) will support the 8% end-to-end objective for services based on ITU-T Rec. G.821. The PO is based on empirical evidence of readily achievable primary rate path performance. It is 50% of the objective values for ES per ITU-T Rec. G.821 and the adopted value is 4%.

The SES performance objective is based on 0.1% end-to-end PO taken directly from ITU-T Rec. G.821. However, since the periods used for BIS/maintenance are short compared to the one month evaluation period suggested in ITU-T Rec. G.821, the additional allowance for radio/satellite systems (per ITU-T Rec. G.821) has not been included. See Table 1a.

6.1.2 Connections using equipment designed according to revised ITU-T Rec. G.826

The ES performance objective will support the 4% end-to-end objective for connections based on ITU-T Rec. G.826. It is 50% of the value for ES per ITU-T Rec. G.826 and the adopted value is 2%. The SES performance objective is based on the 0.1% end-to-end PO defined in ITU-T Rec. G.826.

Table 1a/M.2100 – End-to-end error performance objectives for connections

Parameters (Note)	End-to-end PO for connections based on ITU-T Rec. G.821 (before revision of ITU-T Rec. G.826)	End-to-end PO for connections based on revised ITU-T Rec. G.826
Errored Second Ratio (ESR)	0.04	0.02
Severely Errored Second Ratio (SESR)	0.001	0.001
NOTE – ESR and SESR are defined in 8.3.		

6.2 Primary rate and higher bit rates

The values given in Table 1b for layers at or above the primary rate are selected to maintain alignment with ITU-T Rec. G.826, and are 50% of G.826 values. The APO for ES used in this Recommendation is based on a maximum of 63% of a 2% (primary level), 2.5% (secondary level), 3.75% (tertiary level) and 8% (quaternary level) end-to-end PO as derived from ITU-T Rec. G.826.

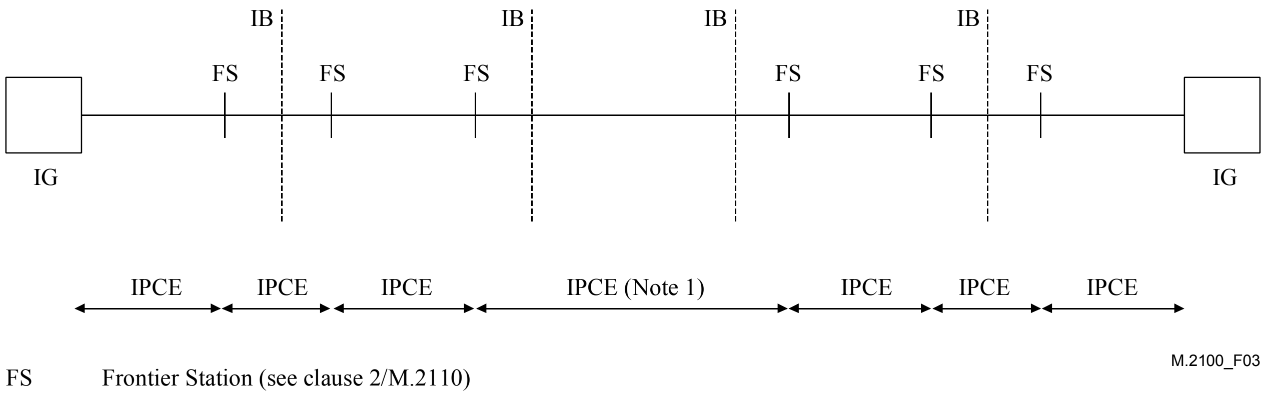
The APO for SES is based on a maximum of 63% of a 0.1% (for every level) end-to-end PO as derived from ITU-T Rec. G.826. However, the basis for calculating ES and SES in ITU-T Rec. G.826, and in this Recommendation, are different and numbers cannot be compared directly.

Table 1b/M.2100 –End-to-end error performance objectives at or above the primary rate

Network level	Errored Seconds Ratio (ESR)	Severely Errored Seconds Ratio (SESR)
Primary	0.02	0.001
Secondary	0.025	0.001
Tertiary	0.0375	0.001
Quaternary	0.08	0.001
NOTE – ESR and SESR are defined in 8.3.		

7 Allocation principles

This clause specifies the allocation of error performance objectives for the international portion of international digital paths, in terms of PCEs as shown in Figure 3.



FS Frontier Station (see clause 2/M.2110)
IB International Border
IG International Gateway

NOTE –This ICPCE crosses two international border and is typically on a satellite or undersea cable transmission system

Figure 3/M.2100 – Example of the components of a primary rate path (such as W, X, Y or Z in Figure 1)

It is the responsibility of each operator to design its network in a way that is consistent with the country allocation for the international path. The allocation of each portion of the international path can be determined from the values given in Table 2b. The lengths referred to in this table are actual route lengths or air-route distances multiplied by an appropriate routing factor (rf), whichever is less. Values of rf are given in Table 2a.

Table 2a/M.2100 – Routing factor

PCE air-route distance	Routing factor (rf)	Calculated PCE length
d < 1000 km	1.5	1.5 × d km
1000 km ≤ d < 1200 km	1500/d	1500 km
d ≥ 1200 km	1.25	1.25 × d km

As shown in Figures 2a and 2b, it is possible that access to the bit stream for a given path may not coincide with the end of a PCE. In this case, or if a transit country has other access points within its network, it may be necessary to make a suballocation for maintenance purposes, e.g., fault localization as described in ITU-T Rec. M.2120. Such suballocations will be the responsibility of the network operator(s) of the country involved, with the following constraints:

– the sum of suballocations may not exceed the allocation of Table 2b for the PCE in question;
– the values of the suballocations must be communicated to all maintenance centres involved before bringing the path into service and after any rearrangement which changes the values.

Table 2b/M.2100 – Allocation of POs to international and inter-country path core elements

PCE classification (Note 2)	Allocation (% of end-to-end POs) (Note 5)
IPCE	
Terminating/transit national networks	
d ≤ 500 km	2.0
500 km < d ≤ 1000 km	3.0
1000 km < d ≤ 2500 km	4.0
2500 km < d ≤ 5000 km	6.0
5000 km < d ≤ 7500 km	8.0
d > 7500 km	10.0
ICPCE	
Non-optical undersea cable	
d ≤ 500 km	
500 km < d ≤ 1000 km	3.0
1000 km < d ≤ 2500 km	4.0
2500 km < d ≤ 5000 km	6.0
d > 5000 km	8.0
Optical undersea cable	
d ≤ 500 km	1.0
d > 500 km	2.5
Satellite	
Normal operation	20.0
Wideband cable restoration mode	(Note 1)
Terrestrial	
d < 300 km (Notes 3 and 4)	0.5

NOTE 1 – The allocated percentage of the POs for the satellite ICPCE will be the same as that for the particular cable restored, with a minimum value of 2.5%. This level of error performance, which is better than that provided by usual satellite portions of ISDN connections, can be achieved through the careful design of specialized wideband, high capacity, C-band carriers which use dedicated facilities.

NOTE 2 – Examples of PCE allocations using Table 2b are given in Annex A.

NOTE 3 – The terrestrial ICPCE is only intended for use in the calculation of end-to-end path BIS/maintenance thresholding applications. It is not intended to be used as the basis for setting maintenance thresholds for the terrestrial ICPCE itself.

NOTE 4 – It is assumed that this length will be less than 300 km. In the case of an unusually long terrestrial ICPCE, the country could transfer a portion of the allocation of its adjacent IPCE to supplement the 0.5% allocation.

NOTE 5 – The allocations of this table are maximum values and may be decreased by bilateral or multilateral agreement. For some very short paths, the M.2100 methodology sometimes gives a larger allocation than ITU-T Rec. G.826. In this case, the Administrations can by bilateral or multilateral agreement choose to lower the allocation given by this Recommendation to reflect the G.826 value, or to take M.2100 values, assuming that the end-to-end G.826 objectives are respected over the long term.

Table 2b/M.2100 – Allocation of POs to international and inter-country path core elements

NOTE 6 – Note that in the case of higher order terminating path supporting lower order transit path, the transit path may have a lower allocation than the sum of the terminating paths. Sensible engineering planning should result in all requirements being met.
NOTE 7 – The 20% allocation is for primary rate links. Applicability to higher bit rates has yet to be validated.

8 Evaluation of error performance events

This clause addresses the evaluation of the error performance events ES and SES from standardized signals using anomalies and defects. The concepts of anomaly and defect are defined in ITU-T Rec. M.20.

In-service evaluation is considered in 8.1, and out-of-service evaluation is considered in 8.2.

NOTE – Only standardized path signals are considered under in-service evaluation; transmission systems with proprietary overhead are not covered. However, both paths and systems can be considered under out-of-service evaluation.

The treatment of the ES and SES counts during the unavailable state is explained in clause 14.

8.1 Evaluation of ES/SES events from in-service measurements

8.1.1 General

Both the ES and SES events are evaluated from in-service anomalies (see 8.1.2) and in-service defects (see 8.1.3) relevant to the path terminating equipment at the network level of interest over a one-second integration period.

8.1.2 In-service anomaly information

An "in-service anomaly" occurs on a path when there is an elemental change of the path overhead from its normal value without a change of state of the total path signal from its normal state, i.e., there is no in-service defect present.

Examples of in-service anomalies are:

– a FAS violation. It should be noted that, for a bunched FAS, an FAS violation occurs if one or more binary errors are present in a single occurrence of the FAS pattern;

– a CRC codeword violation (or its return equivalent, e.g., the "E" bits at 2.048 Mbit/s);

– a parity bit violation;

– an interface code violation (as in ITU-T Rec. G.703). It should be noted that this in-service anomaly is extra redundancy which is not part of the overhead of the binary path signal structure; however, it is required to adapt the binary path signal structure to a form more suited to the transmission media;

– a controlled slip. ITU-T Rec. G.822 gives the performance requirements for controlled slips on primary rate paths which terminate international clock boundaries (see also clause 13).

8.1.3 In-service defect information

An "in-service defect" occurs on a path when there is a change of state of the total path signal from its normal state. A particular in-service defect is evaluated from the persistence (i.e., integration period) of the relevant in-service anomalies; exact details (including any associated consequent actions) are given in the Recommendations dealing with the path termination function for the particular in-service defect considered.

Examples of in-service defects are:

– LOF. ITU-T Rec. G.706 gives the LOF criteria for the basic frame structures (including the primary rate) defined in ITU-T Rec. G.704;
– LOS. ITU-T Rec. G.775 gives the integration criterion for the HDB3 interface code (per ITU-T Rec. G.703). The integration criterion for other interface codes is under study;
– AIS. ITU-T Rec. G.775 gives the integration criterion for 2048 kbit/s path signals structured as per ITU-T Recs G.704 and G.706. The integration criteria for other path signals are under study.

NOTE – An AIS can be considered to cause an effective BER of 0.5 for its duration. If the AIS is of sufficient duration to cause a LOF event at the path level, then for the purposes of ES/SES parameter evaluation it should be considered as a LOF defect. However, a signal with all bits, except the frame alignment in the 1 state, should not be mistaken for an AIS.

8.1.4 Return in-service defect information

The majority of path signals have a facility whereby the detection of the in-service defect LOF at a path terminating equipment results in a remote alarm indication bit being set in the return path overhead. In order to give a degree of protection against transmission errors causing an incorrect decision regarding the status of the remote alarm indication bit, it should be evaluated over an integration period commensurate with its minimum set-state period in the path terminating equipment which originally detected the in-service defect LOF.

8.1.5 ES and SES evaluation from in-service anomaly and defect information at path terminating equipment

This clause shows how anomaly and defect event indicators may be processed into ES and SES events. Tables have been prepared for each network level, from 64 kbit/s subprimary rate to the 97 728/139 264 kbit/s quarternary rate (see Annex B). The tables are all of the same format, each table referring to one level as follows:

– Table B.1: subprimary level (64 kbit/s)
– Table B.2: primary level frame (1544, 2048 kbit/s)
– Table B.3: primary level equipment (1544, 2048 kbit/s)
– Table B.4: secondary level equipment (6312, 8448 kbit/s)
– Table B.5: tertiary level equipment (32 064, 34 368, 44 736 kbit/s)
– Table B.6: quaternary level equipment (97 728, 139 264 kbit/s)

Each table provides guidance for mapping the wide variety of path overhead and the line signal anomaly and defect indicators into the standard ES and SES events.

Where applicable, return in-service anomaly or defect information from a remote path terminating equipment is included in the tables. This allows, when required, a single-ended both-direction monitoring capability.

8.2 Evaluation of ES/SES events from out-of-service measurements

8.2.1 General

The ES and SES events are evaluated from out-of-service anomalies and defects relevant to the test equipment at the network level of interest over the relevant integration period.

8.2.2 Out-of-service anomaly information

An out-of-service anomaly occurs when there is an elemental change of the test signal from its normal value without a change of state of the total test signal from its normal state, i.e., there is no defect.

Out-of-service measurements usually employ a PRBS and, therefore, permit resolution to the bit level. Hence, the bit error is the most basic out-of-service anomaly which can be measured. However, since some test equipment uses PRBSs which are embedded in standardized path signals, it might also be possible to evaluate in-service anomalies (see 8.1.2).

8.2.3 Out-of-service defect information

An out-of-service defect occurs when there is a change of state of the test signal from its normal state. Since some out-of-service test equipment uses PRBSs which are embedded in standardized path signals, it might also be possible to evaluate in-service defects (see 8.1.3).

NOTE – Some test equipment, which uses a PRBS that is not embedded in a standardized path signal, can experience a condition which is referred to as "Loss of Sequence Synchronization".

Loss of sequence synchronization can occur as a consequence of:

– long duration intense error burst;

– long duration AIS;

– uncontrolled bit slip;

– loss of signal.

The criterion to declare "loss of sequence synchronization" is manufacturer-specific and can be highly variable between different manufacturers. The standardized criterion for loss of sequence synchronization in test equipment is given in the O-Series ITU-T Recommendations.

8.2.4 ES and SES evaluation from out-of-service anomaly and defect information in test equipment

Since there will generally be resolution to the bit, the predominant evaluation criteria for ES and SES parameters will be:

– ES: a 1-second period with ≥ 1 bit error or a defect.

– SES: a 1-second period with an integrated BER of $\geq 10^{-3}$ or a defect.

If, in addition, the test equipment uses a PRBS that is embedded in a standardized path signal, then the further ES/SES evaluation criteria referred to in 8.1.5 for in-service anomaly and defect information, can also be utilized.

However, if the test equipment uses a PRBS that is not embedded in a standardized path signal, then the only additional anomaly or defect conditions which can be taken into account are:

– Anomalies: Interface code violations (per ITU-T Rec. G.703).

– Defects: AIS, LOS.

In particular, a 1-second period with ≥ 1 LOS should be considered to give rise to a SES (and an ES).

NOTE – An AIS can be considered to cause an effective BER of 0.5 for its duration. If the AIS is of sufficient duration to cause a BER $\geq 10^{-3}$ in any 1-second period, then it should be considered as a SES (+ES) parameter event. However, a signal with all bits, except the frame alignment in the one state, should not be mistaken for an AIS.

8.3 Definition of ratios

The Errored Second Ratio (ESR) c.q. Severely Errored Second Ratio (SESR) is defined as the ratio of the number of Errored Seconds c.q. Severely Errored Seconds to the total number of seconds in available time in the test period.

9 Performance limits – General considerations

Performance limits relative to Allocated Performance Objective from a long-term perspective are given in Table 3.

9.1 Relationship between performance limits and objectives

The limits in this Recommendation are to be used to indicate the need for actions during maintenance and bringing-into-service. A network maintained to these limits should meet the performance objectives specified in ITU-T Recs G.821 and G.826.

The particular parameters measured, the measurement duration, and the limits used for the procedure need not be identical to those used for specifying the performance objectives as long as they result in network performance which meets these objectives. For example, the error performance objectives refer to long periods, such as one month. However, practical considerations demand that maintenance and BIS limits be based on shorter measurement intervals.

Statistical fluctuations in the occurrence of anomalies mean that one cannot be certain that the long-term objectives are met. The limits on the numbers of events, and the duration of measurements, attempt to ensure that systems, or paths, exhibiting unacceptable or degraded performance can be detected. The only way to ensure that a system, or path, meets network performance objectives is to do continuous measurement over a long period (months).

9.2 Type of limits

Limits are needed for several maintenance functions as defined in ITU-T Rec. M.20. This Recommendation provides limits for three of these functions:

– bringing-into-service (BIS);

– keeping the network operational (maintenance);

– system restoration.

Limits for commissioning (installation and acceptance testing of transmission systems) are not provided in ITU-T Recommendations.

9.2.1 BIS tests/limits

BIS tests are done by measurements using a PRBS between digital terminating points. When a particular path/section is brought into service, the collection of anomalies and defects for the BIS tests shall be done at the actual termination points of this path/section. See ITU-T Rec. M.2110 for further information.These should be long-term measurements for routes with new equipment and long-term (e.g., 24 hour) BIS tests should be used. However, for practical reasons (a new path on a route with many paths already in-service, rearrangements of the network, etc.), the measurements between PEPs may be reduced to a quick measurement and the assessment completed with performance monitoring equipment.

Tests results should be compared to the BIS limits given in this Recommendation.

9.2.2 Maintenance limits

Once entities have been placed into service, supervision of the network requires additional limits, as described in ITU-T Rec. M.20. This supervision is done on an in-service basis using performance monitoring equipment. The supervision process involves analyzing anomalies and defects detected by maintenance entities to determine if the performance level is normal, degraded, or unacceptable. Thus, degraded and unacceptable performance limits are required. In addition, a limit on performance after intervention (repair) is also required. It may be different from the BIS limit.

9.2.3 System restoration limit

A limit on performance after intervention (repair) is required; it is equal to the BIS limit.

10 Performance limits for bringing-into-service

The BIS testing procedures, including how to deal with any period of unavailability during the test, is defined in ITU-T Rec. M.2110. This clause defines the methodology of calculation of BIS performance limits for international paths of every rate of the PDH. The derivation of the limits is a function of a given allocation and the measurement duration, and is based on a pragmatic rule. These limits depend on parameters and objectives from ITU-T Recs G.821 and G.826, and are derived from the values shown in Tables 1a and 1b. The Bringing-into-service Performance Objective (BISPO) is derived from the APO.

The difference between the APO and the BISPO limits is called the ageing margin. This margin should be as large as possible to minimize maintenance interventions. The ageing factor for paths is 0.5.

One limit S is derived from the BISPO for use in BIS testing.

If performance is better than the limit S, the entity can be brought into service with some confidence. Corrective action is required if performance is worse than the limit S.

Continuous in-service monitoring is required to provide sufficient confidence in the long-term performance.

10.1 Calculation of the BIS limits

The BISPO and S limits for each event (ES and SES) are calculated on the basis of the BIS objective, which is fixed at two times better than the APO.

The following steps should be followed:

Step a: Identification of PO

1) Identify the bit rate of the path.

2) Read the PO for the appropriate bit rate from Tables 1a and 1b for ES and SES:
   PO_{es} = x (ratio)

   PO_{ses} = y (ratio)

Step b: Calculation of allocation

3) Identify all PCEs for the entire path, and set N = the total number of PCEs.

4) Label the PCEs as PCE_1 to PCE_N as shown in Figures 2a and 2b.

5) Identify the length, *d*, of each PCE_n. The length, *d*, is either the actual path length or can be estimated by the great circle length between its endpoints multiplied by the appropriate routing factor from Table 2a.

6) Read the allocation, a_n%, (as a percentage of end-to-end PO) for PCE_n from Table 2b. Note that the allocations in Table 2b are maximum values; more stringent values can be used by bilateral or multilateral agreement.

7) Calculate A%, the path allocation, where: $A\% = \sum a_n\%$; i.e., $a_1\% + a_2\% + \ldots + a_N\%$

Step c: Calculation of APO

8) Determine the required Test Period, (TP) where TP = 15 min., 2 hours, or 24 hours. Express TP in seconds, e.g., TP = 900 seconds for a 15-minute test.

9) Calculate the Allocated Performance Objective (APO) counts for ES and SES required from the information already obtained:

$APO_{es} = A \times PO_{es} \times TP \div 100$ (convert A% to ratio)

$APO_{ses} = A \times PO_{ses} \times TP \div 100$ (convert A% to ratio)

Step d: Calculation of BISPO and S values

10) Calculate the BISPOs for the path:

$$BISPO_{es} = \frac{APO_{es}}{2} \qquad\qquad BISPO_{ses} = \frac{APO_{ses}}{2}$$

11) Calculate S values:

$D_{es} = 2\sqrt{BISPO_{es}}$

$S_{es} = BISPO_{es} - D_{es}$

$D_{ses} = 2\sqrt{BISPO_{ses}}$

$S_{ses} = BISPO_{ses} - D_{ses}$

Round all S values to the nearest integer value ≥ 0.

10.2 BIS limits values

By application of the methodology described above, the performance limits for BIS are calculated according to the path allocation and the testing duration. BIS tests described in ITU-T Rec. M.2110 are 15-minute, 2-hour and 24-hour tests.

According to those durations, S values are defined as S_{15}, S_2 and S_{24}. Those S values can be read from the tables given in Annex C.

11 Performance limits for maintenance

Once entities have been placed into service, the supervision of the network requires additional limits, as described in ITU-T Rec. M.20. The supervision process involves analyzing anomalies and defects detected by maintenance entities to determine the performance level. The maintenance procedures are defined in ITU-T Rec. M.2120.

11.1 Performance levels and limits

According to ITU-T Rec. M.20, an entity can be in a limited number of predefined conditions depending on its performance. These conditions are called performance levels and are Unacceptable Performance Level (UPL), Degraded Performance Level (DPL) and Acceptable Performance Level.

Unacceptable performance level: An unacceptable performance level is defined in ITU-T Rec. M.20. The unacceptable performance limit for a given entity is derived from an objective of at least 10 times the APO during a 15-minute period.

Degraded performance level: A degraded performance level is defined in ITU-T Rec. M.20. The degraded performance limit for a given entity is derived from an objective on the order of 0.5 times the APO for transmission systems and 0.75 times the APO for paths. The monitoring duration is a fixed duration of 24 hours.

Performance limit after intervention (repair): This performance limit is derived from an objective in the order of 0.125 times the APO for transmission systems and the same as the BIS limit for paths (see ITU-T Recs M.35 and M.2110).

The boundaries between the performance levels are called performance limits. The performance limits are a function of the APO as follows:

– UPL Limit ≥ 10 × APO where TP = 900 seconds;

– DPL Limit = 0.75 × APO (path) where TP = 86 400 seconds;

– DPL Limit = 0.50 × APO (transmission system) where TP = 86 400 seconds.

In the case of testing performance after repair, a special threshold, "Performance After Repair", is used (see ITU-T Recs M.34 and M.2110) where:

– Performance After Repair = 0.125 × APO (transmission system) for ES and BBE;

– Performance After Repair = 0.5 × APO (path).

Performance levels are bounded by UPL and DPL Limits. The "Performance After Repair" and BIS thresholds are included in the Acceptable range but are not boundaries between performance levels.

11.2 Performance thresholds

Performance limits are defined for ES and SES. Each performance level will have its own threshold to detect crossing of the limit and will require its own measurement duration. Examples of the above principles and objectives to derive limits are shown in Table 3.

Table 3/M.2100 – Performance limits (ES & SES) relative to APO from a long-term perspective (> 1 month)

Transmission systems			Paths		
Limit (relative number of impairments)		**Performance for staff**	**Limit (relative number of impairments)**		**Performance for staff**
Bringing-into-service	0.1	Acceptable	Bringing-into-service	0.5	Acceptable
Performance after repair	0.125		Performance after repair	0.5	
Degraded	0.5	Degraded	Degraded	0.75	Degraded
Unacceptable	> 10	Unacceptable	Unacceptable	> 10	Unacceptable

11.2.1 Use of thresholds

The general strategy for the use of performance monitoring information and thresholds is described in ITU-T Recs M.20 and M.34. These thresholds and information will be reported to operations systems via the TMN for both real time and longer term analysis. When thresholds of unacceptable or degraded performance levels are exceeded, maintenance action should be initiated independently of the performance measurement. Other thresholds may be used for longer term quality analysis. The operations systems will use real-time processing to assign maintenance priorities to these thresholds and information, using the performance supervision process described in ITU-T Rec. M.20.

11.2.2 Types of thresholds

There are two types of thresholds according to the monitoring duration T1 or T2.

Thresholds based on a T1 evaluation period

The monitoring duration T1 is 15-minutes and ES and SES are counted over this period. The T1 period is to assist in detection of transition to or from the unacceptable performance.

A threshold report occurs when an ES or SES threshold is met or exceeded. The reset threshold report, which is an optional feature, occurs when the number of ES and SES is lower than, or equal to, the reset threshold. Those principles are explained in ITU-T Rec. M.2120.

Thresholds based on a T2 evaluation period

The monitoring duration T2 is fixed to a 24-hour value. The T2 period is to assist in detection of transition to the degraded performance.

A threshold report occurs when an ES or SES threshold is met or exceeded over the period of time T2 as explained in ITU-T Rec. M.2120.

11.2.3 Threshold values

Thresholds should be programmable (for both ES and SES) to suit specific operating requirements. In particular, the need for iterative adjustment (with operational experience) of threshold is seen as a likely requirement.

The default unacceptable thresholds for the 15-minute evaluation period are given in Annex D for various allocations.

The degraded performance thresholds for the 24-hour evaluation period are the responsibility of each network operator; 0.75 × APO values are suggested for paths.

12 Long-term quality monitoring/measurement

Performance monitoring history should be kept for at least one year (suggested value) by the management system.

13 Effects of timing impairments on error performance

The following two types of timing impairments may affect the network performance:

– The first one, called controlled slip, is caused by the long-term phase departure between two timing signals at the primary rate path terminating equipment. The number of controlled slips, which produces the loss or the duplication of an octet at the 64 kbit/s level, must fulfil the requirements of ITU-T Rec. G.822.

– The second one, called jitter and wander, is related to the fluctuations in the timing signal. Limits for jitter and wander are defined in ITU-T Recs G.823 and G.824. Those limits are fixed in such a way that a given level of jitter could be applied to the input of a network equipment without producing errors or excessive jitter at its output.

Therefore, for maintenance purposes, the error performance requirements are sufficient to deal with those timing impairments.

14 Availability and unavailability

14.1 Definitions of available and unavailable states

According to 4.2.2/G.821 and 4.7/G.826, the error performance of a path shall only be evaluated whilst the path is in the available state. The reason is that error performance is a parameter which characterizes the service provided by the path. When the service is not available, this characteristic is irrelevant.

In line with this general principle, the evaluation of the error performance shall be based on the numbers of events which happened during available time.

Annex A/G.821 and ITU-T Rec. G.826 further stipulate that a bidirectional service between A and B is only available if both of the two constituent unidirectional services (A to B, and B to A) are available. The reason is that a client is not very much interested in the detailed performance of one direction if the other direction is completely broken.

This Recommendation has a different approach because it is dealing with BIS and maintenance. Maintenance consists of identifying, localizing and correcting failures which affect the performance of a path. In order to be able to carry out these tasks efficiently, the view of an operator working on failures affecting one direction of a bidirectional path should not be obscured by possible unavailability of the other direction.

For this reason, this Recommendation uses only the criteria for a single direction, and not the criterion for a bidirectional path.

The criteria for a single direction are: "A period of unavailable time begins at the onset of ten consecutive SES events. These ten seconds are considered to be part of unavailable time. A new period of available time begins at the onset of ten consecutive non-SES events. These ten seconds are considered to be part of available time."

Hence, in order to evaluate the error performance of a transport entity against the objectives put forward in clause 10, each direction shall be evaluated while disregarding the behaviour of the other direction, and the counting of events for a direction shall only be inhibited when that direction is unavailable.

14.2 Consequences for error performance measurements

To determine the entry into and exit from unavailability, it is necessary to collect SES and to determine unavailability for each direction of a two-way path or connection independently. It should be noted that, when only one direction is in the unavailable state, measurements made on the opposite direction should not be included in the performance assessment of the bidirectional path or connection.

14.3 Inhibiting performance monitoring during unavailable time

During unavailable time, the count of performance events is inhibited. When only one direction of a bidirectional path is unavailable, the count of performance events is inhibited for this direction and continues for the other direction.

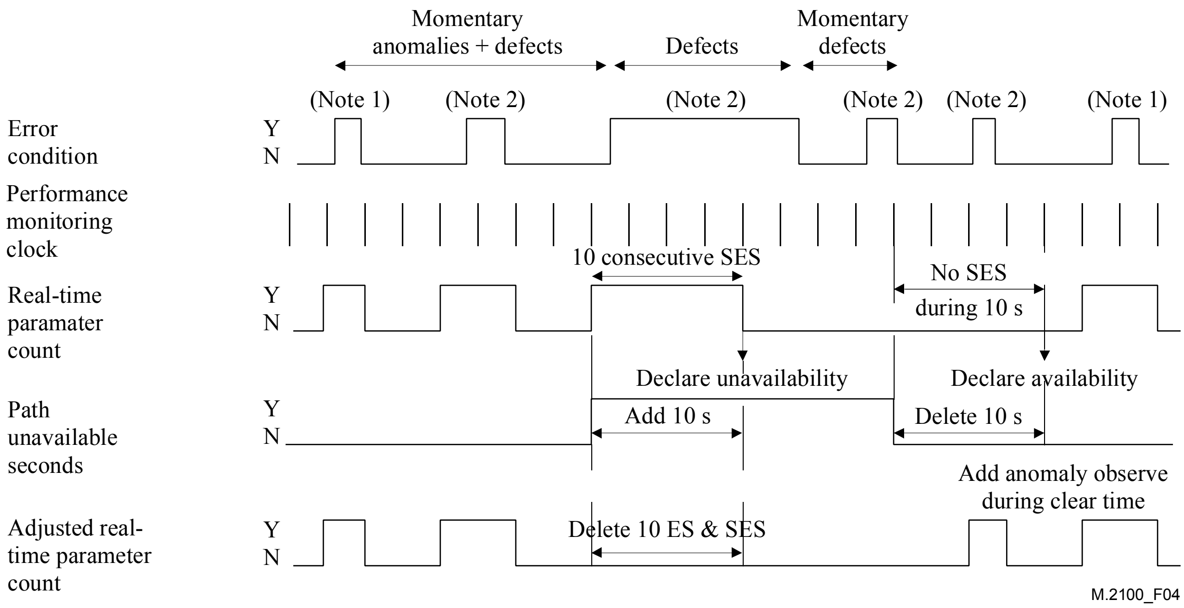
Figure 4 illustrates the rules for determining the unavailable second parameter and for inhibiting other parameter counts. Reading down and left to right, the first row represents the error condition and shows momentary and persistent conditions. It indicates if an error condition exists (Y) or not (N). Error conditions include anomalies and defects as shown. Proceeding in a similar manner, the latter three rows show the procedures for calculating path unavailable seconds, real-time and adjusted real-time parameter counts.

Figure 4 shows the correction to the unavailable counter, and the rules for deleting and adding increments in time in the unavailable second counter. It also shows the count of anomalies during the clearing time interval.

Note that the signal condition transition, or declaration instant of a defect or anomaly condition, is independent of the performance monitoring clock one-second boundaries.

14.4 Unavailability limits

For the time being, unavailability limits are left for negotiation. This subject is under consideration. In general, any transition to the unavailable state should be unacceptable for BIS. For radio and satellite systems, however, unavailable periods due to natural phenomena (e.g., rain fade) may be acceptable.



NOTE 1 – Anomaly (or anomalies).
NOTE 2 – Defect (or defects).

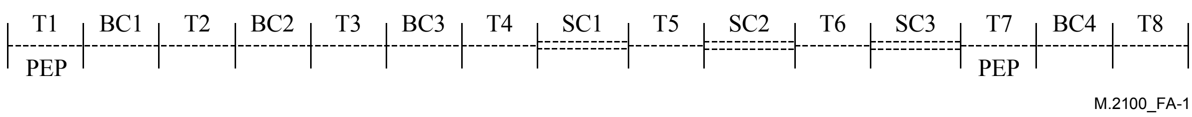
Figure 4/M.2100 – Illustration of performance monitoring inhibiting during unavailable time

Annex A

Example applications of PO allocation from Tables 2a and 2b

This annex provides two examples showing the application of PO Allocation Table described in clause 7. The first example is of a primary rate path which is extremely long and, as such, does not allow for additional tandem paths to further extend the 64 kbit/s connection. The second example is of a complex network where a 64 kbit/s connection is routed over three tandem primary rate paths. The purpose of these examples is to clearly show that the design of individual primary rate paths may result in a wide variation of performance limits. As a result, attention must be paid to this when designing a 64 kbit/s connection so that the high grade international allocation of 40% (if based on ITU-T Rec. G.821) is not exceeded.

Example 1



T	Terminating or transit IPCE
BC	Border Crossing ICPCE
SC	Submarine Cable ICPCE

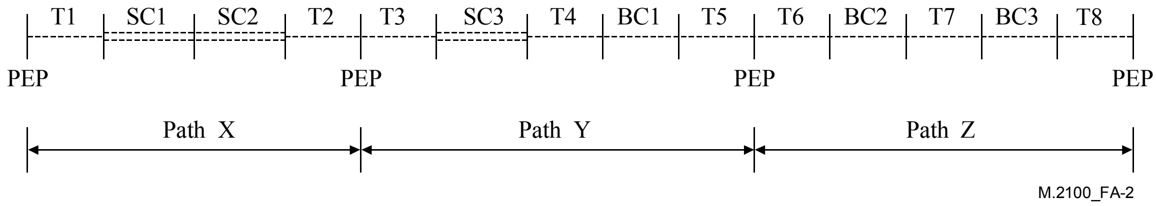
T1-T8	IPCE (Terminating)	1000 km-2500 km	2 × 4.0% = 8.0%
T2-T5	IPCE (Transit)	500 km-1000 km	4 × 3.0% = 12.0%
T6	IPCE (Transit)	<500 km	1 × 2.0% = 2.0%
T7	IPCE (Transit)	>5000 km	1 × 8.0% = 8.0%
SC1-SC3	ICPCE (Optical Submarine Cable)	<500 km	3 × 2.5% = 7.5%
BC1-BC4	ICPCE (Terrestrial)		4 × 0.5% = 2.0%

Total primary rate path allocation = 39.5%

Figure A.1/M.2100 – Example of PO allocation

This path is suitable for 64 kbit/s connections that do not require an additional international primary rate connection such as allowing message traffic to be switched through to another international destination.

Example 2



T	Terminating or transit IPCE		
BC	Border Crossing ICPCE		
SC	Submarine Cable ICPCE		
Path X			
T1	IPCE (Terminating)	500 km-1000 km	1 × 3.0% = 3.0%
T2	IPCE (Terminating)	>5000 km	1 × 8.0% = 8.0%
SC1-SC2	ICPCE (Optical Submarine Cable)	>500 km	2 × 2.5% = 5.0%
		Total primary rate path allocation = 16.0%	
Path Y			
T3,T5	IPCE (Terminating)	<500 km	2 × 2.0% = 4.0%
T4	IPCE (Transit)	500 km-1000 km	1 × 3.0% = 3.0%
SC3	ICPCE (Optical Submarine Cable)	>500 km	1 × 2.5% = 2.5%
BC1	ICPCE (Terrestrial)		1 × 0.5% = 0.5%
		Total primary rate path allocation = 10.0%	
Path Z			
T6	IPCE (Terminating)	500 km-1000 km	1 × 3.0% = 3.0%
T7	IPCE (Transit)	1000 km-2500 km	1 × 4.0% = 4.0%
T8	IPCE(Terminating)	<500 km	1 × 2.0% = 2.0%
BC2-BC3	ICPCE (Terrestrial)		2 × 0.5% = 1.0%
		Total primary rate path allocation = 10.0%	

International 64 kbit/s path allocation: 16.0% + 10.0% + 10.0% = 36.0%

Figure A.2/M.2100 – Example of PO allocation

The total international high grade allocation for a 64 kbits/s connection between terminating countries T1 and T8 is 36.0% which is within the objective of 40%. Since the lowest allocation possible for a primary rate path is 4.5% (two terminating IPCEs < 500 km and one terrestrial ICPCE) adding a fourth primary rate path would exceed the 40% objective. This will be possible if this connection is using equipments designed according to ITU-T Rec. G.826 (maximum of 63%).

Annex B

In-service ES and SES event evaluation criteria

This annex is presented as explanatory text followed by tables. The explanatory text is split into six sections which refer to their respective columns.

Each table contains six columns.

Column 1: Equipment Recommendation and path level (kbit/s)

The left hand column indicates the path bit rate in kbit/s, as well as any relevant qualifying information for the equipment in question and a reference to any relevant equipment Recommendation

Column 2: Path overhead available to derive anomaly and defect information

The second column indicates the path overhead available in the given frame structure suitable for the derivation of anomaly and defect events. The following path overhead functions may be available:

– CRC-4/6 errored block indication;
– E-bits events: Bit 1 of frame 13 and 15 in multiframe – CRC-4 error indication;
– FAS events (binary errors in alignment word);
– Remote defect indication events;
– A-bits: Remote defect indication – Bit 3 in ITU-T Rec. G.704;
– Parity bits;
– S-bits: (multi)frame alignment signal for 1544 kbit/s signals.

Column 3: Anomalies and defects in 1 second

The third column lists the anomaly and defect criteria for 1 second duration. The following techniques may be used:

– LOF alignment;
– LOS: Equipment dependent;
– Errored FAS: Binary errors in any FAS bits/words during the 1 second duration;
– Frame bit-errors: If the equipment can detect binary errors in the FAS word, then an SES can be detected using the suggested value. If the equipment can only detect FAS word violations, then the same number of violated FAS words will lead to an SES;
– A-bits: Remote defect indication – Bit 3 in ITU-T Rec. G.704;
– Remote defect indication bits;
– Parity errors;
– E-bits: Return CRC-4 errored block indicator bits.

In a number of rows, values are suggested when recommended values are not available.

Controlled slips may be introduced at primary rate path end points which are also international clock boundaries (see ITU-T Rec. G.822). A controlled slip is a deterministic impairment which effectively removes or duplicates a single frame of payload at the primary rate path end point. It is classified as an anomaly (see 5.2.2) and should be interpreted as causing an ES (but not an SES).

Column 4: Interpretation for receive direction

Column 4 demonstrates how to interpret anomalies and defects detected using the criteria specified in Column 3 for the path overhead in Column 2. Anomalies lead to ESs, defects lead to SESs and ESs.

Column 5: Interpretation for send direction

Column 5 demonstrates how to interpret anomalies and defects detected by the techniques specified in Column 3. Anomalies lead to ESs; defects lead to SESs and ESs.

Column 6: Remarks

This column provides further explanatory text.

Table B.1/M.2100 – In-service ES and SES event evaluation criteria for subprimary level

Path level (kbit/s)	Path overhead available to derive anomaly/defect information	ES/SES event measurement criteria (anomalies and defects in 1 second)			Remarks
		Anomalies/ and defects in 1 second	Interpretation for receive direction	Interpretation for send direction	
64 (clear)	None	–	–	–	ITU-T Rec. G.821 gives reference performance.
64 ITU-T Rec. H.221	CRC-4 E-bits FAS RDI bit	Under study	Under study	Under study	See ITU-T Rec. H.221 for details. Parameter evaluation criteria is under study.

Table B.2/M.2100 – In-service ES and SES event evaluation criteria for synchronous frame structures used at the primary level

Path level (kbit/s)	Path overhead available to derive anomaly/ defect information	ES/SES event measurement criteria (anomalies and defects in 1 second)			Remarks
		Anomalies/ and defects in 1 second	Interpretation for receive direction	Interpretation for send direction	
1544 (non CRC-6)	FAS S-bit	≥ 1 LOF ≥ 1 LOS ≥ 1 AIS ≥ 1 errored FAS ≥ 8 frame bit errors	ES + SES ES + SES ES + SES ES ES + SES	– – – – –	Send ES resolution limited to part of SES population.
1544 (CRC-6)	CRC-6 FAS LOF	≥ 1 LOF ≥ 1 LOS ≥ 1 AIS ≥ 1 CRC-6 block errors ≥ 320 CRC-6 block errors ≥ 1 LOF sequence	ES + SES ES + SES ES + SES ES ES + SES –	– – – – – ES + SES	Send ES resolution limited to part of SES population (real-time). Total send ES data could be obtained from remote end store via 4 kbit/s data link (method not detailed).
2048 (non CRC-4)	FAS A-bit	≥ 1 LOF ≥ 1 LOS ≥ 1 AIS ≥ 1 errored FAS ≥ 28 frame bit errors ≥ 1 RDI	ES + SES ES + SES ES + SES ES ES + SES –	– – – – – ES + SES	Send ES resolution limited to part of SES population.
2048 (CRC-4)	CRC-4 E-bits FAS A-bit	≥ 1 LOF ≥ 1 LOS ≥ 1 AIS ≥ 1 CRC-4 block errors ≥ 805 CRC-4 block errors ≥ 1 E-bit ≥ 805 E-bits ≥ 1 RDI	ES + SES ES + SES ES + SES ES ES + SES – – –	– – – – – ES ES + SES ES + SES	Both send and receive ES and SES resolution possible in real-time from single end.

Table B.3/M.2100 – In-service ES and SES event evaluation criteria for equipment which operates at the primary level

Equipment and path level (kbit/s)	Path overhead available to derive anomaly/ defect information	ES/SES event measurement criteria (anomalies and defects in 1 second)			Remarks
		Anomalies/ and defects in 1 second	Interpretation for receive direction	Interpretation for send direction	
ITU-T Rec. G.724 ITU-T Rec. G.733 ITU-T Rec. G.762 ITU-T Rec. G.794 1544					Uses ITU-T Recs G.704 and G.706. See appropriate entry in Table B.2.
ITU-T Rec. G.734 1544	FAS RDI bit	≥ 1 LOF ≥ 1 LOS ≥ 1 AIS ≥ 1 errored FAS ≥ 8 frame bit errors ≥ 1 RDI	ES + SES ES + SES ES + SES ES ES + SES –	– – – – – ES + SES	
ITU-T Rec. G732 ITU-T Rec. G.735 ITU-T Rec. G.736 ITU-T Rec. G.737 ITU-T Rec. G.738 ITU-T Rec. G.739 ITU-T Rec. G.761 ITU-T Rec. G.793 2048					Uses ITU-T Recs G.704 and G.706. See appropriate entry in Table B.2.

Table B.4/M.2100 – In-service ES and SES event evaluation criteria for equipment which operates at the secondary level

Equipment and path level (kbit/s)	Path overhead available to derive anomaly/ defect information	ES/SES event measurement criteria (anomalies and defects in 1 second)			Remarks
		Anomalies/ and defects in 1 second	Interpretation for receive direction	Interpretation for send direction	
ITU-T Rec. G.743 6312	FAS RDI bit (if equipped)	≥ 1 LOF ≥ 1 LOS ≥ 1 AIS ≥ 1 errored FAS ≥ 21 frame bit errors ≥ 1 RDI	ES + SES ES + SES ES + SES ES ES + SES –	– – – – – ES + SES	Send ES resolution limited to part of SES population (if RDI equipped).
ITU-T Rec. G.747 6312	Parity bit FAS RDI bit	≥ 1 LOF ≥ 1 LOS ≥ 1 AIS ≥ 1 Parity error, or ≥ 1 errored FAS ≥ 2000 Parity errors or ≥ 28 frame bit errors ≥ 1 RDI	ES + SES ES + SES ES + SES ES ES ES + SES ES + SES –	– – – – – – – ES + SES	The method of using Parity and/or errored FAS for receive ES and SES evaluation is under study. Send ES resolution limited to part of SES population.
ITU-T Rec. G.742 8448	FAS RDI bit	≥ LOF ≥ LOS ≥ AIS ≥ 1 errored FAS ≥ 41 frame bit errors ≥ 1 RDI	ES + SES ES + SES ES + SES ES ES + SES –	– – – – – ES + SES	Send ES resolution limited to part of SES population.
ITU-T Rec. G.745 8448	FAS RDI bit	≥ 1 LOF ≥ 1 LOS ≥ 1 AIS ≥ 1 errored FAS ≥ 22 frame bit errors ≥ 1 RDI	ES + SES ES + SES ES + SES ES ES + SES –	– – – – – ES + SES	Send ES resolution limited to part of SES population.

Table B.5/M.2100 – In-service ES and SES event evaluation criteria for equipment which operates at the tertiary level

Equipment and path level (kbit/s)	Path overhead available to derive anomaly/ defect information	ES/SES event measurement criteria (anomalies and defects in 1 second)			Remarks
		Anomalies/ and defects in 1 second	Interpretation for receive direction	Interpretation for send direction	
ITU-T Rec. G.752 32 064	FAS RDI bit	≥ 1 LOF ≥ 1 LOS ≥ 1 AIS ≥ 1 errored FAS ≥ 31 frame bit errors ≥ 1 RDI	ES + SES ES + SES ES + SES ES ES + SES –	– – – – – ES + SES	Send ES resolution limited to part of SES population.
ITU-T Rec. G.751 34 368	FAS RDI bit	≥ 1 LOF ≥ 1 LOS ≥ 1 AIS ≥ 1 errored FAS ≥ 52 frame bit errors ≥ 1 RDI	ES + SES ES + SES ES + SES ES ES + SES –	– – – – – ES + SES	Send ES resolution limited to part of SES population.
ITU-T Rec. G.753 34 368	FAS RDI bit	≥ 1 LOF ≥ 1 LOS ≥ 1 AIS ≥ 1 errored FAS ≥ 32 frame bit errors ≥ 1 RDI	ES + SES ES + SES ES + SES ES ES + SES –	– – – – – ES + SES	Send ES resolution limited to part of SES population.
ITU-T Rec. G.752 44 736	Parity bits FAS RDI bit (if equiped)	≥ 1 LOF ≥ 1 LOS ≥ 1 AIS ≥ 1 Parity error, or ≥ 1 errored FAS ≥ 2444 Parity errors, or ≥ 5 frame bit errors ≥ 1 RDI	ES + SES ES + SES ES + SES ES ES ES + SES ES + SES –	– – – – – – – ES + SES	The method of using Parity and/or errored FAS for receive ES and SES evaluation is under study. Send ES resolution limited to part of SES population (if RDI equipped).

Table B.6/M.2100 – In-service ES and SES event evaluation criteria for equipment which operates at the quaternary level

Equipment and path level (kbit/s)	Path overhead available to derive anomaly/ defect information	ES/SES event measurement criteria (anomalies and defects in 1 second)			Remarks
		Anomalies/ and defects in 1 second	Interpretation for receive direction	Interpretation for send direction	
ITU-T Rec. G.752 97 728	Parity bit FAS RDI bit	≥ 1 LOF ≥ 1 LOS ≥ 1 AIS ≥ 1 Parity error, or ≥ 1 errored FAS ≥ 21 000 Parity errors, or ≥ 152 frame bit errors ≥ 1 RDI	ES + SES ES + SES ES + SES ES ES ES + SES ES + SES –	– – – – – – – ES + SES	The method of using Parity and/or errored FAS for receive ES and SES evaluation is under study. Send ES resolution limited to part of SES population.
ITU-T Rec. G.751 139 264	FAS RDI bit	≥ 1 LOF ≥ 1 LOS ≥ 1 AIS ≥ 1 errored FAS ≥ 69 frame bit errors ≥ 1 RDI	ES + SES ES + SES ES + SES ES ES + SES –	– – – – – ES + SES	Send ES resolution limited to part of SES population.
ITU-T Rec. G.754 139 264	FAS RDI bit	≥ 1 LOF ≥ 1 LOS ≥ 1 AIS ≥ 1 errored FAS ≥ 104 frame bit errors ≥ 1 RDI	ES + SES ES + SES ES + SES ES ES + SES –	– – – – – ES + SES	Send ES resolution limited to part of SES population.
ITU-T Rec. G.755 139 264	Parity bit FAS RDI bit	≥ 1 LOF ≥ 1 LOS ≥ 1 AIS ≥ 1 Parity error, or ≥ 1 errored FAS ≥ 43 800 Parity errors or ≥ 655 frame bit errors ≥ 1 RDI	ES + SES ES + SES ES + SES ES ES ES + SES ES + SES –	– – – – – – – ES + SES	The method of using Parity and/or errored FAS for receive ES and SES evaluation is under study. Send ES resolution limited to part of SES population.

Annex C

Values for bringing-into-service limits for international digital paths

Tables have been prepared for each network level from 64 kbit/s to 139 264 kbit/s.

– Tables C.1: Subprimary level.

Table C.1a is applicable to connections based on ITU-T Rec. G.821 (i.e., using equipment designed before the adoption of ITU-T Rec. G.826 and Table C.1b is applicable to connections based on ITU-T Rec. G.826.

– Table C.2: Primary level.
– Table C.3: Secondary level.
– Table C.4: Tertiary level.
– Table C.5: Quaternary level.

Table C.1a/M.2100 – BIS performance limits for subprimary level based on ITU-T Rec. G.821

	15mn		2 hours		24 hours	
	ES	SES	ES	SES	ES	SES
Path Alloc.	S15	S15	S2	S2	S24	S24
0.2%	0	0	0	0	0	0
0.5%	0	0	0	0	3	0
1.0%	0	0	0	0	9	0
1.5%	0	0	0	0	16	0
2.0%	0	0	0	0	23	0
2.5%	0	0	0	0	30	0
3.0%	0	0	0	0	37	0
3.5%	0	0	0	0	45	0
4.0%	0	0	0	0	52	0
4.5%	0	0	0	0	60	0
5.0%	0	0	0	0	68	0
5.5%	0	0	0	0	76	0
6.0%	0	0	0	0	83	0
6.5%	0	0	0	0	91	0
7.0%	0	0	0	0	99	0
7.5%	0	0	0	0	107	0
8.0%	0	0	0	0	115	0
8.5%	0	0	0	0	123	0
9.0%	0	0	0	0	131	0
9.5%	0	0	0	0	139	0
10.0%	0	0	0	0	147	0
10.5%	0	0	0	0	155	0
11.0%	0	0	0	0	163	0
11.5%	0	0	0	0	171	1
12.0%	0	0	0	0	179	1
12.5%	0	0	0	0	187	1
13.0%	0	0	0	0	195	1
13.5%	0	0	0	0	203	1
14.0%	0	0	0	0	211	1
14.5%	0	0	0	0	219	1
15.0%	0	0	0	0	227	1
15.5%	0	0	0	0	235	2
16.0%	0	0	0	0	243	2
16.5%	0	0	14	0	251	2
17.0%	0	0	15	0	259	2
17.5%	0	0	15	0	268	2
18.0%	0	0	16	0	276	2
18.5%	0	0	16	0	284	2
19.0%	0	0	17	0	292	2
19.5%	0	0	17	0	300	3
20.0%	0	0	18	0	308	3

	15mn		2 hours		24 hours	
	ES	SES	ES	SES	ES	SES
Path Alloc.	S15	S15	S2	S2	S24	S24
20.5%	0	0	19	0	317	3
21.0%	0	0	19	0	325	3
21.5%	0	0	20	0	333	3
22.0%	0	0	20	0	341	3
22.5%	0	0	21	0	349	3
23.0%	0	0	22	0	358	4
23.5%	0	0	22	0	366	4
24.0%	0	0	23	0	374	4
24.5%	0	0	23	0	382	4
25.0%	0	0	24	0	390	4
25.5%	0	0	25	0	399	4
26.0%	0	0	25	0	407	5
26.5%	0	0	26	0	415	5
27.0%	0	0	26	0	423	5
27.5%	0	0	27	0	432	5
28.0%	0	0	28	0	440	5
28.5%	0	0	28	0	448	5
29.0%	0	0	29	0	456	5
29.5%	0	0	29	0	465	6
30.0%	0	0	30	0	473	6
30.5%	0	0	31	0	481	6
31.0%	0	0	31	0	489	6
31.5%	0	0	32	0	498	6
32.0%	0	0	33	0	506	6
32.5%	0	0	33	0	514	7
33.0%	0	0	34	0	522	7
33.5%	0	0	34	0	531	7
34.0%	0	0	35	0	539	7
34.5%	0	0	36	0	547	7
35.0%	0	0	36	0	556	7
35.5%	0	0	37	0	564	8
36.0%	0	0	37	0	572	8
36.5%	0	0	38	0	580	8
37.0%	0	0	39	0	589	8
37.5%	0	0	39	0	597	8
38.0%	0	0	40	0	605	8
38.5%	0	0	41	0	614	8
39.0%	0	0	41	0	622	9
39.5%	0	0	42	0	630	9
40.0%	0	0	42	0	639	9

Table C.1b/M.2100 – BIS performance limits for subprimary level based on ITU-T Rec. G.826

	15mn		2 hours		24 hours			15mn		2 hours		24 hours	
	ES	SES	ES	SES	ES	SES		ES	SES	ES	SES	ES	SES
Path Alloc.	S15	S15	S2	S2	S24	S24	Path Alloc.	S15	S15	S2	S2	S24	S24
0.2%	0	0	0	0	0	0	19.5%	0	0	7	0	143	3
0.5%	0	0	0	0	0	0	20.0%	0	0	7	0	147	3
1.0%	0	0	0	0	3	0	20.5%	0	0	7	0	151	3
1.5%	0	0	0	0	6	0	21.0%	0	0	7	0	155	3
2.0%	0	0	0	0	9	0	21.5%	0	0	8	0	159	3
2.5%	0	0	0	0	12	0	22.0%	0	0	8	0	163	3
3.0%	0	0	0	0	16	0	22.5%	0	0	8	0	167	3
3.5%	0	0	0	0	19	0	23.0%	0	0	8	0	171	4
4.0%	0	0	0	0	23	0	23.5%	0	0	9	0	175	4
4.5%	0	0	0	0	26	0	24.0%	0	0	9	0	179	4
5.0%	0	0	0	0	30	0	24.5%	0	0	9	0	183	4
5.5%	0	0	0	0	34	0	25.0%	0	0	10	0	187	4
6.0%	0	0	0	0	37	0	25.5%	0	0	10	0	191	4
6.5%	0	0	0	0	41	0	26.0%	0	0	10	0	195	5
7.0%	0	0	1	0	45	0	26.5%	0	0	10	0	199	5
7.5%	0	0	1	0	49	0	27.0%	0	0	11	0	203	5
8.0%	0	0	1	0	52	0	27.5%	0	0	11	0	207	5
8.5%	0	0	1	0	56	0	28.0%	0	0	11	0	211	5
9.0%	0	0	1	0	60	0	28.5%	0	0	11	0	215	5
9.5%	0	0	2	0	64	0	29.0%	0	0	12	0	219	5
10.0%	0	0	2	0	68	0	29.5%	0	0	12	0	223	6
10.5%	0	0	2	0	72	0	30.0%	0	0	12	0	227	6
11.0%	0	0	2	0	76	0	30.5%	0	0	13	0	231	6
11.5%	0	0	3	0	79	1	31.0%	0	0	13	0	235	6
12.0%	0	0	3	0	83	1	31.5%	0	0	13	0	239	6
12.5%	0	0	3	0	87	1	32.0%	0	0	13	0	243	6
13.0%	0	0	3	0	91	1	32.5%	0	0	14	0	247	7
13.5%	0	0	3	0	95	1	33.0%	0	0	14	0	251	7
14.0%	0	0	4	0	99	1	33.5%	0	0	14	0	255	7
14.5%	0	0	4	0	103	1	34.0%	0	0	15	0	259	7
15.0%	0	0	4	0	107	1	34.5%	0	0	15	0	264	7
15.5%	0	0	4	0	111	2	35.0%	0	0	15	0	268	7
16.0%	0	0	5	0	115	2	35.5%	0	0	15	0	272	8
16.5%	0	0	5	0	119	2	36.0%	0	0	16	0	276	8
17.0%	0	0	5	0	123	2	36.5%	0	0	16	0	280	8
17.5%	0	0	6	0	127	2	37.0%	0	0	16	0	284	8
18.0%	0	0	6	0	131	2	37.5%	0	0	17	0	288	8
18.5%	0	0	6	0	135	2	38.0%	0	0	17	0	292	8
19.0%	0	0	6	0	139	2	38.5%	0	0	17	0	296	8

Table C.1b/M.2100 – BIS performance limits for subprimary level based on ITU-T Rec. G.826

	15mn		2 hours		24 hours	
	ES	SES	ES	SES	ES	SES
Path Alloc.	S15	S15	S2	S2	S24	S24
39.0%	0	0	17	0	300	9
39.5%	0	0	18	0	304	9
40.0%	0	0	18	0	308	9
40.5%	0	0	18	0	313	9
41.0%	0	0	19	0	317	9
41.5%	0	0	19	0	321	9
42.0%	0	0	19	0	325	10
42.5%	0	0	20	0	329	10
43.0%	0	0	20	0	333	10
43.5%	0	0	20	0	337	10
44.0%	0	0	20	0	341	10
44.5%	0	0	21	0	345	10
45.0%	0	0	21	0	349	11
45.5%	0	0	21	0	353	11
46.0%	0	0	22	0	358	11
46.5%	0	0	22	0	362	11
47.0%	0	0	22	0	366	11
47.5%	0	0	23	0	370	11
48.0%	0	0	23	0	374	12
48.5%	0	0	23	0	378	12
49.0%	0	0	23	0	382	12
49.5%	0	0	24	0	386	12
50.0%	0	0	24	0	390	12
50.5%	0	0	24	0	395	12
51.0%	0	0	25	0	399	13
51.5%	0	0	25	0	403	13
52.0%	0	0	25	0	407	13
52.5%	0	0	26	0	411	13
53.0%	0	0	26	0	415	13
53.5%	0	0	26	0	419	13
54.0%	0	0	26	0	423	14
54.5%	0	0	27	0	427	14
55.0%	0	0	27	0	432	14
55.5%	0	0	27	0	436	14
56.0%	0	0	28	0	440	14
56.5%	0	0	28	0	444	15
57.0%	0	0	28	0	448	15
57.5%	0	0	29	0	452	15
58.0%	0	0	29	0	456	15
58.5%	0	0	29	0	460	15
59.0%	0	0	29	0	465	15
59.5%	0	0	30	0	469	16
60.0%	0	0	30	0	473	16
60.5%	0	0	30	0	477	16
61.0%	0	0	31	0	481	16
61.5%	0	0	31	0	485	16
62.0%	0	0	31	0	489	16
62.5%	0	0	32	0	494	17
63.0%	0	0	32	0	498	17

Table C.2/M.2100 – BIS performance limits for primary level

	15mn		2 hours		24 hours	
	ES	SES	ES	SES	ES	SES
Path Alloc.	S15	S15	S2	S2	S24	S24
0.2%	0	0	0	0	0	0
0.5%	0	0	0	0	0	0
1.0%	0	0	0	0	3	0
1.5%	0	0	0	0	6	0
2.0%	0	0	0	0	9	0
2.5%	0	0	0	0	12	0
3.0%	0	0	0	0	16	0
3.5%	0	0	0	0	19	0
4.0%	0	0	0	0	23	0
4.5%	0	0	0	0	26	0
5.0%	0	0	0	0	30	0
5.5%	0	0	0	0	34	0
6.0%	0	0	0	0	37	0
6.5%	0	0	0	0	41	0
7.0%	0	0	1	0	45	0
7.5%	0	0	1	0	49	0
8.0%	0	0	1	0	52	0
8.5%	0	0	1	0	56	0
9.0%	0	0	1	0	60	0
9.5%	0	0	2	0	64	0
10.0%	0	0	2	0	68	0
10.5%	0	0	2	0	72	0
11.0%	0	0	2	0	76	0
11.5%	0	0	3	0	79	1
12.0%	0	0	3	0	83	1
12.5%	0	0	3	0	87	1
13.0%	0	0	3	0	91	1
13.5%	0	0	3	0	95	1
14.0%	0	0	4	0	99	1
14.5%	0	0	4	0	103	1
15.0%	0	0	4	0	107	1
15.5%	0	0	4	0	111	2
16.0%	0	0	5	0	115	2
16.5%	0	0	5	0	119	2
17.0%	0	0	5	0	123	2
17.5%	0	0	6	0	127	2
18.0%	0	0	6	0	131	2
18.5%	0	0	6	0	135	2
19.0%	0	0	6	0	139	2

	15mn		2 hours		24 hours	
	ES	SES	ES	SES	ES	SES
Path Alloc.	S15	S15	S2	S2	S24	S24
19.5%	0	0	7	0	143	3
20.0%	0	0	7	0	147	3
20.5%	0	0	7	0	151	3
21.0%	0	0	7	0	155	3
21.5%	0	0	8	0	159	3
22.0%	0	0	8	0	163	3
22.5%	0	0	8	0	167	3
23.0%	0	0	8	0	171	4
23.5%	0	0	9	0	175	4
24.0%	0	0	9	0	179	4
24.5%	0	0	9	0	183	4
25.0%	0	0	10	0	187	4
25.5%	0	0	10	0	191	4
26.0%	0	0	10	0	195	5
26.5%	0	0	10	0	199	5
27.0%	0	0	11	0	203	5
27.5%	0	0	11	0	207	5
28.0%	0	0	11	0	211	5
28.5%	0	0	11	0	215	5
29.0%	0	0	12	0	219	5
29.5%	0	0	12	0	223	6
30.0%	0	0	12	0	227	6
30.5%	0	0	13	0	231	6
31.0%	0	0	13	0	235	6
31.5%	0	0	13	0	239	6
32.0%	0	0	13	0	243	6
32.5%	0	0	14	0	247	7
33.0%	0	0	14	0	251	7
33.5%	0	0	14	0	255	7
34.0%	0	0	15	0	259	7
34.5%	0	0	15	0	264	7
35.0%	0	0	15	0	268	7
35.5%	0	0	15	0	272	8
36.0%	0	0	16	0	276	8
36.5%	0	0	16	0	280	8
37.0%	0	0	16	0	284	8
37.5%	0	0	17	0	288	8
38.0%	0	0	17	0	292	8
38.5%	0	0	17	0	296	8

Table C.2/M.2100 – BIS performance limits for primary level

	15mn		2 hours		24 hours	
	ES	SES	ES	SES	ES	SES
Path Alloc.	S15	S15	S2	S2	S24	S24
39.0%	0	0	17	0	300	9
39.5%	0	0	18	0	304	9
40.0%	0	0	18	0	308	9
40.5%	0	0	18	0	313	9
41.0%	0	0	19	0	317	9
41.5%	0	0	19	0	321	9
42.0%	0	0	19	0	325	10
42.5%	0	0	20	0	329	10
43.0%	0	0	20	0	333	10
43.5%	0	0	20	0	337	10
44.0%	0	0	20	0	341	10
44.5%	0	0	21	0	345	10
45.0%	0	0	21	0	349	11
45.5%	0	0	21	0	353	11
46.0%	0	0	22	0	358	11
46.5%	0	0	22	0	362	11
47.0%	0	0	22	0	366	11
47.5%	0	0	23	0	370	11
48.0%	0	0	23	0	374	12
48.5%	0	0	23	0	378	12
49.0%	0	0	23	0	382	12
49.5%	0	0	24	0	386	12
50.0%	0	0	24	0	390	12
50.5%	0	0	24	0	395	12
51.0%	0	0	25	0	399	13

	15mn		2 hours		24 hours	
	ES	SES	ES	SES	ES	SES
Path Alloc.	S15	S15	S2	S2	S24	S24
51.5%	0	0	25	0	403	13
52.0%	0	0	25	0	407	13
52.5%	0	0	26	0	411	13
53.0%	0	0	26	0	415	13
53.5%	0	0	26	0	419	13
54.0%	0	0	26	0	423	14
54.5%	0	0	27	0	427	14
55.0%	0	0	27	0	432	14
55.5%	0	0	27	0	436	14
56.0%	0	0	28	0	440	14
56.5%	0	0	28	0	444	15
57.0%	0	0	28	0	448	15
57.5%	0	0	29	0	452	15
58.0%	0	0	29	0	456	15
58.5%	0	0	29	0	460	15
59.0%	0	0	29	0	465	15
59.5%	0	0	30	0	469	16
60.0%	0	0	30	0	473	16
60.5%	0	0	30	0	477	16
61.0%	0	0	31	0	481	16
61.5%	0	0	31	0	485	16
62.0%	0	0	31	0	489	16
62.5%	0	0	32	0	494	17
63.0%	0	0	32	0	498	17

Table C.3/M.2100 – BIS performance limits for secondary level

	15mn		2 hours		24 hours			15mn		2 hours		24 hours	
	ES	SES	ES	SES	ES	SES		ES	SES	ES	SES	ES	SES
Path Alloc.	S15	S15	S2	S2	S24	S24	Path Alloc.	S15	S15	S2	S2	S24	S24
0.2%	0	0	0	0	0	0	19.5%	0	0	9	0	182	3
0.5%	0	0	0	0	1	0	20.0%	0	0	10	0	187	3
1.0%	0	0	0	0	4	0	20.5%	0	0	10	0	192	3
1.5%	0	0	0	0	8	0	21.0%	0	0	10	0	197	3
2.0%	0	0	0	0	12	0	21.5%	0	0	11	0	202	3
2.5%	0	0	0	0	17	0	22.0%	0	0	11	0	207	3
3.0%	0	0	0	0	21	0	22.5%	0	0	11	0	212	3
3.5%	0	0	0	0	26	0	23.0%	0	0	12	0	217	4
4.0%	0	0	0	0	30	0	23.5%	0	0	12	0	222	4
4.5%	0	0	0	0	35	0	24.0%	0	0	12	0	227	4
5.0%	0	0	0	0	39	0	24.5%	0	0	13	0	232	4
5.5%	0	0	1	0	44	0	25.0%	0	0	13	0	237	4
6.0%	0	0	1	0	49	0	25.5%	0	0	13	0	242	4
6.5%	0	0	1	0	53	0	26.0%	0	0	14	0	247	5
7.0%	0	0	1	0	58	0	26.5%	0	0	14	0	252	5
7.5%	0	0	2	0	63	0	27.0%	0	0	14	0	257	5
8.0%	0	0	2	0	68	0	27.5%	0	0	15	0	263	5
8.5%	0	0	2	0	73	0	28.0%	0	0	15	0	268	5
9.0%	0	0	2	0	77	0	28.5%	0	0	16	0	273	5
9.5%	0	0	3	0	82	0	29.0%	0	0	16	0	278	5
10.0%	0	0	3	0	87	0	29.5%	0	0	16	0	283	6
10.5%	0	0	3	0	92	0	30.0%	0	0	17	0	288	6
11.0%	0	0	4	0	97	0	30.5%	0	0	17	0	293	6
11.5%	0	0	4	0	102	1	31.0%	0	0	17	0	298	6
12.0%	0	0	4	0	107	1	31.5%	0	0	18	0	303	6
12.5%	0	0	5	0	112	1	32.0%	0	0	18	0	308	6
13.0%	0	0	5	0	117	1	32.5%	0	0	18	0	314	7
13.5%	0	0	5	0	122	1	33.0%	0	0	19	0	319	7
14.0%	0	0	6	0	127	1	33.5%	0	0	19	0	324	7
14.5%	0	0	6	0	132	1	34.0%	0	0	20	0	329	7
15.0%	0	0	6	0	137	1	34.5%	0	0	20	0	334	7
15.5%	0	0	6	0	142	2	35.0%	0	0	20	0	339	7
16.0%	0	0	7	0	147	2	35.5%	0	0	21	0	344	8
16.5%	0	0	7	0	152	2	36.0%	0	0	21	0	349	8
17.0%	0	0	7	0	157	2	36.5%	0	0	21	0	354	8
17.5%	0	0	8	0	162	2	37.0%	0	0	22	0	360	8
18.0%	0	0	8	0	167	2	37.5%	0	0	22	0	365	8
18.5%	0	0	8	0	172	2	38.0%	0	0	23	0	370	8
19.0%	0	0	9	0	177	2	38.5%	0	0	23	0	375	8

Table C.3/M.2100 – BIS performance limits for secondary level

	15mn		2 hours		24 hours	
	ES	SES	ES	SES	ES	SES
Path Alloc.	**S15**	**S15**	**S2**	**S2**	**S24**	**S24**
39.0%	0	0	23	0	380	9
39.5%	0	0	24	0	385	9
40.0%	0	0	24	0	390	9
40.5%	0	0	24	0	396	9
41.0%	0	0	25	0	401	9
41.5%	0	0	25	0	406	9
42.0%	0	0	26	0	411	10
42.5%	0	0	26	0	416	10
43.0%	0	0	26	0	421	10
43.5%	0	0	27	0	426	10
44.0%	0	0	27	0	432	10
44.5%	0	0	27	0	437	10
45.0%	0	0	28	0	442	11
45.5%	0	0	28	0	447	11
46.0%	0	0	29	0	452	11
46.5%	0	0	29	0	457	11
47.0%	0	0	29	0	463	11
47.5%	0	0	30	0	468	11
48.0%	0	0	30	0	473	12
48.5%	0	0	30	0	478	12
49.0%	0	0	31	0	483	12
49.5%	0	0	31	0	488	12
50.0%	0	0	32	0	494	12
50.5%	0	0	32	0	499	12
51.0%	0	0	32	0	504	13
51.5%	0	0	33	0	509	13
52.0%	0	0	33	0	514	13
52.5%	0	0	34	0	519	13
53.0%	0	0	34	0	525	13
53.5%	0	0	34	0	530	13
54.0%	0	0	35	0	535	14
54.5%	0	0	35	0	540	14
55.0%	0	0	35	0	545	14
55.5%	0	0	36	0	550	14
56.0%	0	0	36	0	556	14
56.5%	0	0	37	0	561	15
57.0%	0	0	37	0	566	15
57.5%	0	0	37	0	571	15
58.0%	0	0	38	0	576	15
58.5%	0	0	38	0	582	15
59.0%	0	0	39	0	587	15
59.5%	0	0	39	0	592	16
60.0%	0	0	39	0	597	16
60.5%	0	0	40	0	602	16
61.0%	0	0	40	0	607	16
61.5%	0	0	40	0	613	16
62.0%	0	0	41	0	618	16
62.5%	0	0	41	0	623	17
63.0%	0	0	42	0	628	17

Table C.4/M.2100 – BIS performance limits for tertiary level

	15mn		2 hours		24 hours			15mn		2 hours		24 hours	
	ES	SES	ES	SES	ES	SES		ES	SES	ES	SES	ES	SES
Path Alloc.	S15	S15	S2	S2	S24	S24	Path Alloc.	S15	S15	S2	S2	S24	S24
0.2%	0	0	0	0	0	0	19.5%	0	0	16	0	280	3
0.5%	0	0	0	0	2	0	20.0%	0	0	17	0	288	3
1.0%	0	0	0	0	8	0	20.5%	0	0	17	0	296	3
1.5%	0	0	0	0	14	0	21.0%	0	0	18	0	303	3
2.0%	0	0	0	0	21	0	21.5%	0	0	18	0	311	3
2.5%	0	0	0	0	28	0	22.0%	0	0	19	0	319	3
3.0%	0	0	0	0	35	0	22.5%	0	0	19	0	326	3
3.5%	0	0	0	0	42	0	23.0%	0	0	20	0	334	4
4.0%	0	0	1	0	49	0	23.5%	0	0	20	0	342	4
4.5%	0	0	1	0	56	0	24.0%	0	0	21	0	349	4
5.0%	0	0	2	0	63	0	24.5%	0	0	22	0	357	4
5.5%	0	0	2	0	70	0	25.0%	0	0	22	0	365	4
6.0%	0	0	2	0	77	0	25.5%	0	0	23	0	372	4
6.5%	0	0	3	0	85	0	26.0%	0	0	23	0	380	5
7.0%	0	0	3	0	92	0	26.5%	0	0	24	0	388	5
7.5%	0	0	4	0	99	0	27.0%	0	0	24	0	396	5
8.0%	0	0	4	0	107	0	27.5%	0	0	25	0	403	5
8.5%	0	0	5	0	114	0	28.0%	0	0	26	0	411	5
9.0%	0	0	5	0	122	0	28.5%	0	0	26	0	419	5
9.5%	0	0	6	0	129	0	29.0%	0	0	27	0	426	5
10.0%	0	0	6	0	137	0	29.5%	1	0	27	0	434	6
10.5%	0	0	7	0	144	0	30.0%	1	0	28	0	442	6
11.0%	0	0	7	0	152	0	30.5%	1	0	28	0	450	6
11.5%	0	0	8	0	159	1	31.0%	1	0	29	0	457	6
12.0%	0	0	8	0	167	1	31.5%	1	0	29	0	465	6
12.5%	0	0	9	0	174	1	32.0%	1	0	30	0	473	6
13.0%	0	0	9	0	182	1	32.5%	1	0	31	0	481	7
13.5%	0	0	10	0	189	1	33.0%	1	0	31	0	488	7
14.0%	0	0	10	0	197	1	33.5%	1	0	32	0	496	7
14.5%	0	0	11	0	204	1	34.0%	1	0	32	0	504	7
15.0%	0	0	11	0	212	1	34.5%	1	0	33	0	512	7
15.5%	0	0	12	0	219	2	35.0%	1	0	34	0	519	7
16.0%	0	0	12	0	227	2	35.5%	1	0	34	0	527	8
16.5%	0	0	13	0	235	2	36.0%	1	0	35	0	535	8
17.0%	0	0	13	0	242	2	36.5%	1	0	35	0	543	8
17.5%	0	0	14	0	250	2	37.0%	1	0	36	0	550	8
18.0%	0	0	14	0	257	2	37.5%	1	0	36	0	558	8
18.5%	0	0	15	0	265	2	38.0%	1	0	37	0	566	8
19.0%	0	0	16	0	273	2	38.5%	1	0	38	0	574	8

Table C.4/M.2100 – BIS performance limits for tertiary level

	15mn		2 hours		24 hours	
	ES	SES	ES	SES	ES	SES
Path Alloc.	S15	S15	S2	S2	S24	S24
39.0%	1	0	38	0	582	9
39.5%	2	0	39	0	589	9
40.0%	2	0	39	0	597	9
40.5%	2	0	40	0	605	9
41.0%	2	0	40	0	613	9
41.5%	2	0	41	0	620	9
42.0%	2	0	42	0	628	10
42.5%	2	0	42	0	636	10
43.0%	2	0	43	0	644	10
43.5%	2	0	43	0	652	10
44.0%	2	0	44	0	659	10
44.5%	2	0	45	0	667	10
45.0%	2	0	45	0	675	11
45.5%	2	0	46	0	683	11
46.0%	2	0	46	0	691	11
46.5%	2	0	47	0	698	11
47.0%	2	0	48	0	706	11
47.5%	2	0	48	0	714	11
48.0%	2	0	49	0	722	12
48.5%	2	0	49	0	730	12
49.0%	3	0	50	0	737	12
49.5%	3	0	50	0	745	12
50.0%	3	0	51	0	753	12
50.5%	3	0	52	0	761	12
51.0%	3	0	52	0	769	13
51.5%	3	0	53	0	777	13
52.0%	3	0	53	0	784	13
52.5%	3	0	54	0	792	13
53.0%	3	0	55	0	800	13
53.5%	3	0	55	0	808	13
54.0%	3	0	56	0	816	14
54.5%	3	0	56	0	823	14
55.0%	3	0	57	0	831	14
55.5%	3	0	58	0	839	14
56.0%	3	0	58	0	847	14
56.5%	3	0	59	0	855	15
57.0%	3	0	59	0	863	15
57.5%	3	0	60	0	870	15
58.0%	4	0	61	0	878	15
58.5%	4	0	61	0	886	15
59.0%	4	0	62	0	894	15
59.5%	4	0	62	0	902	16
60.0%	4	0	63	0	910	16
60.5%	4	0	64	0	917	16
61.0%	4	0	64	0	925	16
61.5%	4	0	65	0	933	16
62.0%	4	0	65	0	941	16
62.5%	4	0	66	0	949	17
63.0%	4	0	67	0	957	17

Table C.5/M.2100 – BIS performance limits for quaternary level

	15mn		2 hours		24 hours	
	ES	SES	ES	SES	ES	SES
Path Alloc.	**S15**	**S15**	**S2**	**S2**	**S24**	**S24**
0.2%	0	0	0	0	2	0
0.5%	0	0	0	0	9	0
1.0%	0	0	0	0	23	0
1.5%	0	0	0	0	37	0
2.0%	0	0	1	0	52	0
2.5%	0	0	2	0	68	0
3.0%	0	0	3	0	83	0
3.5%	0	0	4	0	99	0
4.0%	0	0	5	0	115	0
4.5%	0	0	6	0	131	0
5.0%	0	0	7	0	147	0
5.5%	0	0	8	0	163	0
6.0%	0	0	9	0	179	0
6.5%	0	0	10	0	195	0
7.0%	0	0	11	0	211	0
7.5%	0	0	12	0	227	0
8.0%	0	0	13	0	243	0
8.5%	0	0	15	0	259	0
9.0%	0	0	16	0	276	0
9.5%	0	0	17	0	292	0
10.0%	0	0	18	0	308	0
10.5%	0	0	19	0	325	0
11.0%	0	0	20	0	341	0
11.5%	0	0	22	0	358	1
12.0%	0	0	23	0	374	1
12.5%	0	0	24	0	390	1
13.0%	0	0	25	0	407	1
13.5%	0	0	26	0	423	1
14.0%	1	0	28	0	440	1
14.5%	1	0	29	0	456	1
15.0%	1	0	30	0	473	1
15.5%	1	0	31	0	489	2
16.0%	1	0	33	0	506	2
16.5%	1	0	34	0	522	2
17.0%	1	0	35	0	539	2
17.5%	1	0	36	0	556	2
18.0%	1	0	37	0	572	2
18.5%	1	0	39	0	589	2
19.0%	2	0	40	0	605	2
19.5%	2	0	41	0	622	3
20.0%	2	0	42	0	639	3
20.5%	2	0	44	0	655	3
21.0%	2	0	45	0	672	3
21.5%	2	0	46	0	689	3
22.0%	2	0	47	0	705	3
22.5%	2	0	49	0	722	3
23.0%	3	0	50	0	738	4
23.5%	3	0	51	0	755	4
24.0%	3	0	52	0	772	4
24.5%	3	0	54	0	789	4
25.0%	3	0	55	0	805	4
25.5%	3	0	56	0	822	4
26.0%	3	0	58	0	839	5
26.5%	3	0	59	0	855	5
27.0%	3	0	60	0	872	5
27.5%	4	0	61	0	889	5
28.0%	4	0	63	0	905	5
28.5%	4	0	64	0	922	5
29.0%	4	0	65	0	939	5
29.5%	4	0	67	0	956	6
30.0%	4	0	68	0	972	6
30.5%	4	0	69	0	989	6
31.0%	4	0	70	0	1006	6
31.5%	5	0	72	0	1023	6
32.0%	5	0	73	0	1039	6
32.5%	5	0	74	0	1056	7
33.0%	5	0	76	0	1073	7
33.5%	5	0	77	0	1090	7
34.0%	5	0	78	0	1106	7
34.5%	5	0	79	0	1123	7
35.0%	6	0	81	0	1140	7
35.5%	6	0	82	0	1157	8
36.0%	6	0	83	0	1174	8
36.5%	6	0	85	0	1190	8
37.0%	6	0	86	0	1207	8
37.5%	6	0	87	0	1224	8
38.0%	6	0	89	0	1241	8
38.5%	6	0	90	0	1258	8

Table C.5/M.2100 – BIS performance limits for quarternary level

	15mn		2 hours		24 hours	
	ES	**SES**	**ES**	**SES**	**ES**	**SES**
Path Alloc.	**S15**	**S15**	**S2**	**S2**	**S24**	**S24**
39.0%	7	0	91	0	1274	9
39.5%	7	0	92	0	1291	9
40.0%	7	0	94	0	1308	9
40.5%	7	0	95	0	1325	9
41.0%	7	0	96	0	1342	9
41.5%	7	0	98	0	1358	9
42.0%	7	0	99	0	1375	10
42.5%	7	0	100	0	1392	10
43.0%	8	0	102	0	1409	10
43.5%	8	0	103	0	1426	10
44.0%	8	0	104	0	1443	10
44.5%	8	0	106	0	1459	10
45.0%	8	0	107	0	1476	11
45.5%	8	0	108	0	1493	11
46.0%	8	0	109	0	1510	11
46.5%	9	0	111	0	1527	11
47.0%	9	0	112	0	1544	11
47.5%	9	0	113	0	1561	11
48.0%	9	0	115	0	1577	12
48.5%	9	0	116	0	1594	12
49.0%	9	0	117	0	1611	12
49.5%	9	0	119	0	1628	12
50.0%	10	0	120	0	1645	12
50.5%	10	0	121	0	1662	12
51.0%	10	0	123	0	1679	13

	15mn		2 hours		24 hours	
	ES	**SES**	**ES**	**SES**	**ES**	**SES**
Path Alloc.	**S15**	**S15**	**S2**	**S2**	**S24**	**S24**
51.5%	10	0	124	0	1695	13
52.0%	10	0	125	0	1712	13
52.5%	10	0	127	0	1729	13
53.0%	10	0	128	0	1746	13
53.5%	10	0	129	0	1763	13
54.0%	11	0	131	0	1780	14
54.5%	11	0	132	0	1797	14
55.0%	11	0	133	0	1814	14
55.5%	11	0	135	0	1830	14
56.0%	11	0	136	0	1847	14
56.5%	11	0	137	0	1864	15
57.0%	11	0	139	0	1881	15
57.5%	12	0	140	0	1898	15
58.0%	12	0	141	0	1915	15
58.5%	12	0	143	0	1932	15
59.0%	12	0	144	0	1949	15
59.5%	12	0	145	0	1966	16
60.0%	12	0	147	0	1983	16
60.5%	12	0	148	0	1999	16
61.0%	13	0	149	0	2016	16
61.5%	13	0	151	0	2033	16
62.0%	13	0	152	0	2050	16
62.5%	13	0	153	0	2067	17
63.0%	13	0	155	0	2084	17

Annex D

Default unacceptable performance level thresholds for international digital paths

Tables D.1 and D.2 provide the default unacceptable performance level set and reset thresholds for international digital paths.

Table D.1/M.2100 – Default unacceptable performance level set thresholds for international digital paths

Allocation (%)	Primary level		Secondary level		Tertiary level		Quaternary level	
	ES	SES	ES	SES	ES	SES	ES	SES
0.2-34	80	10	80	10	100	10	120	10
35-63	120	15	120	15	150	15	180	15

Table D.2/M.2100 – Default unacceptable performance level reset thresholds for international digital paths

Allocation (%)	Primary level		Secondary level		Tertiary level		Quaternary level	
	ES	SES	ES	SES	ES	SES	ES	SES
0.2-34	1	0	1	0	1	0	1	0
35-63	2	0	2	0	3	0	4	0

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