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CONSULTATIVE COMMITTEE

MAINTENANCE: INTERNATIONAL TRANSPORT NETWORK

PERFORMANCE LIMITS FOR BRINGING-INTO-SERVICE AND MAINTENANCE OF INTERNATIONAL DIGITAL PATHS, SECTIONS AND TRANSMISSION SYSTEMS

Recommendation M.2100

FOREWORD

The CCITT (the International Telegraph and Telephone Consultative Committee) is a permanent organ of the International Telecommunication Union (ITU). CCITT is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The Plenary Assembly of CCITT which meets every four years, establishes the topics for study and approves Recommendations prepared by its Study Groups. The approval of Recommendations by the members of CCITT between Plenary Assemblies is covered by the procedure laid down in CCITT Resolution No. 2 (Melbourne, 1988).

Recommendation M.2100 was revised by Study Group IV and was approved under the Resolution No. 2 procedure on the 5th of October 1992.

CCITT NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized private operating agency.

Recommendation M.2100

PERFORMANCE LIMITS FOR BRINGING-INTO-SERVICE AND MAINTENANCE OF INTERNATIONAL DIGITAL PATHS, SECTIONS AND TRANSMISSION SYSTEMS

(Melbourne 1988; revised and renumbered in 1992)

Abstract

This Recommendation provides limits for bringing-into-service and maintenance of international digital paths sections, and transmission systems at every level of the plesiochronous digital hierarchy from 64 kbit/s. Error, timing and availability performance are considered. A method for deriving ES and SES from in-service measurement is given for all hierarchical levels.

Keywords

bringing-into-service limit;

maintenance limit;

errored second;

severely errored second;

performance objective;

performance allocation;

errored performance parameter;

availability;

unavailability;

digital section;

digital path;

digital transmission system.

Abbreviations

AIS	alarm indication signal
BER	bit error ratio
BIS	bringing-into-service
CRC	cyclic redundancy check
ES	errored second
FAS	frame alignment signal
ICPCE	inter-country path core element
IDCT	international digital transmission center
IPCE	international path core element
ISDN	integrated services digital network
LOF	loss of frame
LOS	loss of signal
PCE	path core element
PDH	plesichronous digital hierarchy
PEP	path end point

PRBS	pseudo-random bit sequence
PRPEP	primary rate path end point
RPO	reference performance objective
SDH	synchronous digital hierarchy
SES	severely errored second
TMN	telecommunication management network

1 General

The purpose of this Recommendation is to provide limits for bringing-into-service, and limits for maintenance of digital paths, sections and transmission systems in order to achieve the performance objectives given for a multiservice environment. These objectives include error performance (Recommendation G.821 [1]), timing performance (Recommendation G.822 [2]) and availability. This Recommendation defines the parameters and their associated objectives in order to respect the principles given in Recommendations M.20 [37], M.32 [38] and M.34 [39].

The methods and procedures for applying these limits are described in Recommendation M.2110 [42] for the bringing-into-service procedures and in Recommendation M.2120 [41] 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 today's digital equipment and systems.

In the future this or companion Recommendations will cover all digital paths, sections and transmission systems which operate at 64 kbit/s and at every higher level of the hierarchy, including the ISDN subscriber access described in Recommendation I.412 [3], for both the PDH hierarchy described in Recommendation G.702 [4] and the SDH described in Recommendations G.707 [5], G.708 [6] and G.709 [7].

Currently this Recommendation covers the error performance limits of the primary-rate path layer of the PDH network and in-service parameter evaluation criteria up to quarternary layer.

1.1 *Convention*

Throughout this Recommendation the terms "path", "section" and "transmission system" should be understood as digital. Also RPO is used for reference performance objective for both ES and SES unless only one is specifically indicated.

2 Error performance for the PDH 64 kbit/s and primary rate

2.1 *Reference models*

The physical relationship between international paths of the primary rate network layer and paths in the 64 kbit/s network layer is illustrated in Figure 1/M.2100.

An extension of this model showing a primary rate path (such as W, X, Y or Z in Figure 1/M.2100) in terms of PCEs (see § 2.1.2) is given in Figure 2/M.2100.

2.1.1 *Hypothetical reference performance model for international primary rate paths and 64 kbit/s paths*

Key points to note in Figure 1/M.2100 are:

i) paths of the primary rate network layer can serve either

- peer-layer clients, e.g. an H_{12} channel in the case of 2048 kbit/s paths; or
- lower order clients, e.g. 64 kbit/s section of a path in the 64 kbit/s network layer;

ii) the international portion of the 64 kbit/s path is given 40% of the end-to-end error RPO (see § 2.2 and Table 1/M.2100);

iii) 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 RPOs are given in Table 2/M.2100;

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

v) sensible engineering planning is required to ensure that tandemed international primary rate paths respect the 40% allocation.

2.1.2 *Path core elements*

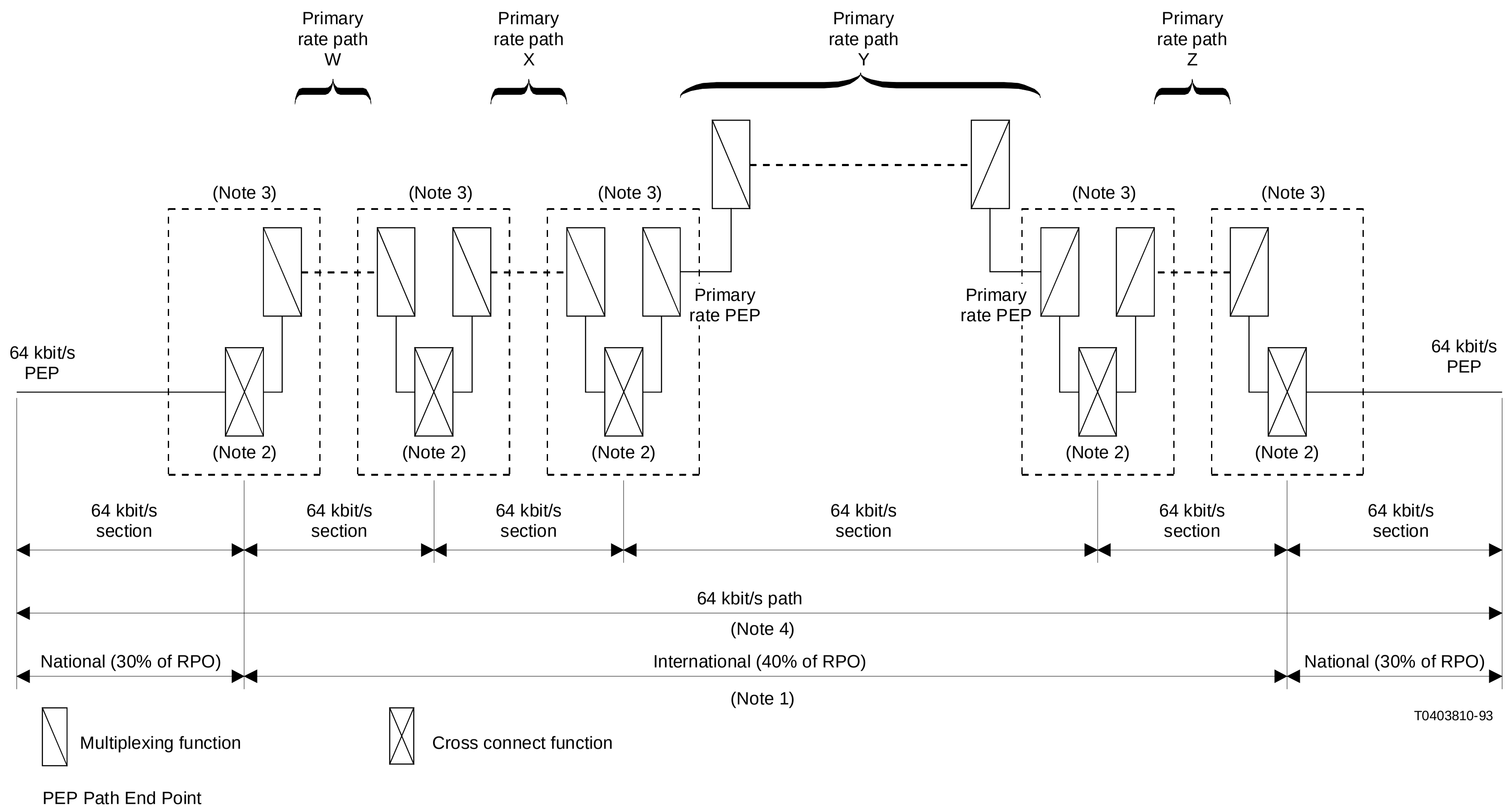
An international digital path has been partitioned in geographical terms for the purpose of allocating the RPO. These partitions have been titled Path core elements.

Two types of international PCEs are used :

- an IPCE is between an international PEP and a frontier station 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.

2.2 *Performance objectives*

The RPO for ES used in this Recommendation is based on 40% of a 4% end-to-end RPO proposed in Recommendation M.1300 [40]. The RPO will also support the 8% end-to-end objective for services based on Recommendation G.821 [1]. The RPO is based on empirical evidence of readily achievable primary rate path performance.



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 £ 40% of the total RPO.

Note 2 – For a 64 kbit/s switched connection this point has historically been refered 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 IDTC (International Digital Transmission Center).

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

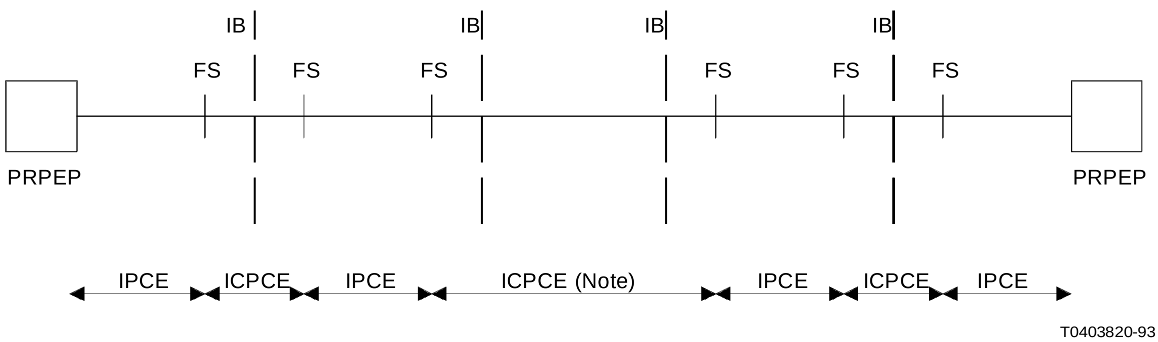
The RPO for SES is based on 40% of a 0.1% end-to-end RPO taken directly from Recommendation G.821. However, since the periods used for BIS/maintenance are short compared to the one month evaluation period suggested in Recommendation G.821, the additional allowance for radio/satellite systems (per Recommen-dation G.821) has not been included.

TABLE 1/M.2100

End-to-end error reference performance objectives

Parameter (Note)	End-to-End RPO (maximum % of time)
Errored Seconds (ES)	4.0
Severely Errored Seconds (SES)	0.1

Note – The ES and SES parameters are defined in §§ 2.5.3.4 and 2.5.4.4.



PRPEP Primary Rate Path End Point
FS Frontier Station (See Recommendation M.2110 [42], § 2)

International Border

Note – This ICPCE crosses two international borders and is typically on a satellite or undersea cable transmission system.

FIGURE 2/M.2100

Example of the expansion of a primary rate path (such as W, X, Y, or Z in Figure 1/M.2100) to show PCEs

2.3 *Allocation principles*

This section specifies the allocation of primary rate error performance objectives for the international portion of Figure 1/M.2100, in terms of PCEs as shown in Figure 2/M.2100.

The international portion is based on the model of four tandem primary rate international paths as shown in Figure 1/M.2100. The total allocation for all paths in the international portion of a connection should not exceed 40% of the end-to-end RPOs given in Table 1/M.2100.

It is the responsibility of each country to design its network in a way that is consistent with its country allocation for the international path. The allocation of each portion of the international path can be determined from the values given in Table 2/M.2100.

TABLE 2/M.2100

Allocation of RPOs to international and inter-country path core elements

PCE classification (Notes 1 and 3)	Allocation (% of end-to-end RPOs) (Note 6)
IPCE	
Terminating/transit national networks:	
$d \leq 500$ km	2.0
500 km $< d \leq$ 1000 km	3.0
1000 km $< d \leq$ 2500 km	4.0
2500 km $< d \leq$ 5000 km	6.0
$d >$ 5000 km	8.0
ICPCE	
Non optical undersea cable:	
$d \leq 500$ km	2.0
500 km $< d \leq$ 1000 km	3.0
1000 km $< d \leq$ 2500 km	4.0
2500 km $< d \leq$ 5000 km	6.0
$d >$ 5000 km	8.0
Optical undersea cable:	
$d \leq 500$ km	1.0
$d >$ 500 km	2.5
Satellite:	
Normal operation	20.0
Wideband cable restoration mode	(Note 2)
Terrestrial:	
$d <$ 300 km (Notes 4 and 5)	0.5

Note 1 – Distances (*d*) refer to route length agreed during initial negotiations.

Note 2 – The allocated percentage of the RPOs 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 3 – Examples of PCE allocations using Table 2/M.2100 are given in Annex A.

Note 4 – 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. The RPO value of 0.5% is the maximum allowable, and this may be reduced by bilateral agreement.

Note 5 – 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 6 – The allocations of this table are maximum values and may be decreased by bilateral or multilateral agreement.

As shown in Figure 3/M.2100, 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 sub-allocation for maintenance purposes, e.g. fault localization as described in Recommendation M.2120 [41]. Such sub-allocations will be the responsibility of the national network operator(s) of the country involved, with the following constraints:

- the sum of sub-allocations may not exceed the allocation of Table 2/M.2100 for the PCE in question;
- the values of the sub-allocations must be communicated to all maintenance centers involved before bringing the path into service and after any rearrangement which changes the values.

2.4 *Performance limits*

(See Table 3/M.2100.)

2.4.1 *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. These procedures are intended to result in network performance objectives of the relevant G-Series Recommendations.

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 means 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).

2.4.2 *Error performance parameters transfer characteristic*

The error performance parameters' transfer characteristic between 64 kbit/s and primary rate is assumed in this Recommendation to be 1 to 1. Therefore, one table for performance parameters applies for both levels.

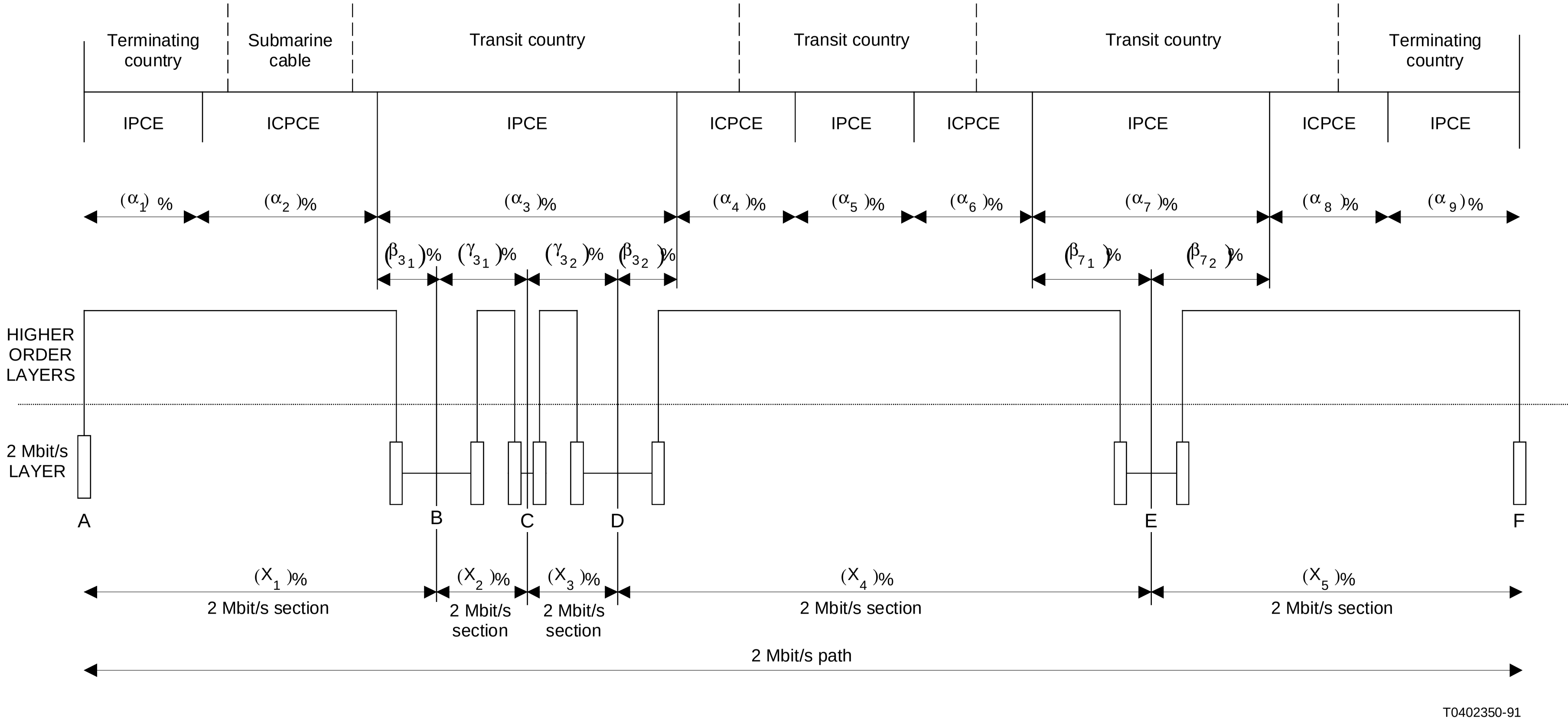
2.4.3 *Type of limits*

Limits are needed for several maintenance functions as defined in Recommendation M.20 [37]. This Recommendation provides limits for three of these functions:

- bringing-into-service;
- keeping the network operational (maintenance);
- system restoration.

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

BIS tests are done by measurements using a PRBS between digital terminating points. These should be long-term measurements for routes with new equipment. 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.



– α_i are given in Table 2/M.2100
– Path allocation = $\alpha_1 + \alpha_2 + ... + \alpha_9 = \Sigma\alpha_i$ (%)
– β_i and γ_i values are the responsibility of the national network operators for country *i* with the following constraints:

– $\beta_{i_1} + \Sigma\gamma_i + \beta_{i_1} \le \alpha_i$ for each PCE $_i$;
– β_i values must be communicated to each control station.

International Border

FIGURE 3/M.2100

Example of apportionment for an international primary rate path

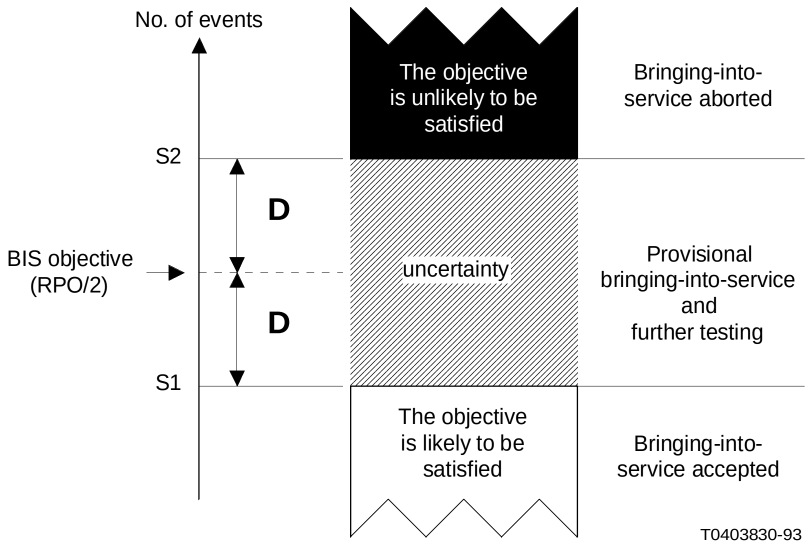
Once entities have been placed into service, supervision of the network requires additional limits, as described in Recommendation M.20 [37]. This supervision is done on an in-service basis using performance monitoring equipment. The supervision process involves analysing anomalies and defects detected 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.

2.4.3.1 *Bringing-into-service limits*

The BIS testing procedure is defined in § 4.2 of Recommendation M.2110 [42]. 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 Recommendation G.821 [1], and are shown in Table 1/M.2100.

The difference between the RPO and the BIS limit is called the ageing margin. This margin should be as large as possible to minimize maintenance interventions.

Two limits S1 and S2 are provided for use in BIS testing, as shown in Figure 4/M.2100.



Note – For derivation of D see § 2.6.1.

FIGURE 4 /M.2100

Bringing-into-service limits and conditions

If performance is better than the first limit S1, the entity can be brought into service with some confidence. If performance is between the two limits, further testing is necessary and the entity can only be provisionally accepted. Corrective action is required if performance is worse than the second limit S2.

The ageing margin for transmission systems will depend on the procedures of individual administrations. A stringent limit which is 0.1 times the RPO should be used when previous commissioning tests have not been conducted. When commissioning tests have been made, the out-of-service test for BIS can be conducted for a shorter period and does not require the same stringent limits.

The ageing margin for paths and sections is 0.5 times the RPO. The testing duration will obviously be limited to no more than a few days.

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

2.4.3.2 *Maintenance limits*

2.4.3.2.1 *Unacceptable performance limits*

An unacceptable performance level is defined in Recommendation M.20 [37].

The unacceptable performance limit for a given entity is derived from an objective of at least 10 times the RPO.

2.4.3.2.2 *Degraded performance limits*

A degraded performance level is defined in Recommendation M.20 [37].

The degraded performance limit for a given entity is derived from an objective on the order of 0.5 times the RPO for transmission systems and 0.75 times the RPO for paths and sections. The monitoring duration may be a fixed duration that depends on the level in the digital hierarchy.

2.4.3.2.3 *Performance limit after intervention (repair)*

This performance limit is derived from an objective in the order of 0.125 times the RPO for transmission systems and the same as the BIS limit for paths and sections (see Recommendations M.35 [43] and M.2110 [42]).

2.4.4 *Performance limit thresholds*

Performance limits are defined for ES and SES. Each performance limit will have its own threshold and will require its own measurement duration. Examples of the above principles and objectives to derive limits are shown in Table 3/M.2100.

2.4.5 *Use of threshold*

The general strategy for the use of performance monitoring information and thresholds is described in Recommendations M.20 [37] and M.34 [39]. 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 reached, maintenance action should be initiated independently of the performance measurement. Other thresholds may be used for maintenance and 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 Recommendation M.20 [37].

2.5 *Evaluation of error performance parameters*

2.5.1 *Scope*

This paragraph addresses the evaluation of the error performance parameters ES and SES from standardized signals using anomalies and defects. The concepts of anomaly and defect are defined in Recommendation M.20 [37].

TABLE 3/M.2100

Performance limits (ES & SES) relative to RPO
from a long-term perspective (see Note)

Transmission systems			Paths and sections		
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, Performance after repair	0.5	Acceptable
Performance after repair	0.125				
Degraded	0.5	Degraded	Degraded	0.75	Degraded
Reference performance objective	1		Reference performance objective	1	
Unacceptable	> 10	Unacceptable	Unacceptable	> 10	Unacceptable

Note – The values indicated in this table have to be understood only from a long-term (greater than one month) perspective.

In-service evaluation is considered in § 2.5.3 and out-of-service evaluation is considered in § 2.5.4.

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

ES and SES parameters should only be evaluated during the available state (see § 5) for error performance assessment purposes.

2.5.2 *Network level parameter identification*

When referencing ES and SES measurements above the 64 kbit/s network level, a network level subscript identifier should be used. For example, an ES at the 1.544 Mbit/s network level should be annotated as $ES_{1.5M}$.

2.5.3 *Evaluation of ES/SES parameters from in-service measurements*

2.5.3.1 *General*

Both the ES and SES parameters are evaluated from in-service anomalies (see § 2.5.3.2) and in-service defects (see § 2.5.3.3) relevant to the path terminating equipment at the network level of interest over a one-second integration period.

2.5.3.2 *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:

– *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;

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

– *parity bit violation*;

– *interface code violation* (as in Recommendation G.703 [8]) – 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;

– *controlled slip* – Recommendation G.822 [2] gives the performance requirements for controlled slips on primary rate paths which terminate international clock boundaries (see also § 4).

2.5.3.3 *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 – Recommendation G.706 [9] gives the LOF criteria for the basic frame structures (including the primary rate) defined in Recommendation G.704 [10];

– LOS – Recommendation O.162 [11] gives the integration criterion for the HDB3 interface code (per Recommendation G.703 [8]). The integration criterion for other interface codes is under study;

– AIS – Recommendation O.162 [11] gives the integration criterion for 2048 kbit/s path signals structured as per Recommendations G.704 [10] and G.706 [9]. 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 (see § 2.5.3.4) 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.

2.5.3.4 *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.

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

Path terminating equipment should evaluate ES and SES parameters using the per-second in-service anomaly and defect criteria given in Tables 4/M.2100 to 9/M.2100. Each table gives the more common forms of standardized path signals at the 64 kbit/s reference network level through to the 139 264 kbit/s quaternary network level.

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.

TABLE 4/M.2100

In-service ES and SES parameter evaluation criteria for sub-primary level

Path level (kbit/s)	Path overhead available to derive anomaly/defect information	ES/SES Parameter 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	–	–	–	G.821 [1] gives reference performance.
64 H.221 [12]	CRC4 E-bits FAS RAI bit	Under study	Under study	Under study	See H.221 [12] for details. Parameter evaluation criteria are Under study

2.5.4 *Evaluation of ES/SES parameters from out-of-service measurements*

Note – This paragraph is currently restricted to the 64 kbit/s and primary rate network levels. Higher network levels are under study.

2.5.4.1 *General*

The ES and SES parameters 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.

TABLE 5/M.2100

In-service ES and SES parameter 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 Parameter 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-CRC6)	FAS S-bit	≥ 1 LOF ≥ 1 LOS ≥ 1 errored FAS ≥ 8 frame bit errors	ES + SES ES + SES ES ES + SES	– – – –	Send ES resolution limited to part of SES population.
1544 (CRC6)	CRC6 FAS LOF	≥ 1 LOF ≥ 1 LOS ≥ 1 CRC6 blk errs ≥ 320 CRC6 blk errs ≥ 1 LOF sequence	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-CRC4)	FAS A-bit	≥ 1 LOF ≥ 1 LOS ≥ 1 errored FAS ≥ *c* frame bit errors (*c* is US; 28 frame bit errors are suggested) ≥ *d* A-bits (*d* is US)	ES + SES ES + SES ES ES + SES –	– – – – ES + SES	Send ES resolution limited to part of SES population.
2048 (CRC4)	CRC4 E bits FAS A-bit	≥ 1 LOF ≥ 1 LOS ≥ 1 CRC4 blk errs ≥ 805 CRC4 blk errs ≥ 1 E-bit ≥ 805 E-bits ≥ *e* A-bits (*e* is US)	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.

US Under study.

TABLE 6/M.2100

In-service ES and SES parameter evaluation criteria
for equipment which operates at the primary level

Equip. Rec. and Path level (kbit/s)	Path overhead available to derive anomaly/defect information	ES/SES Parameter Measurement Criteria (Anomalies and Defects in 1 second)			Remarks
		Anomalies and defects in 1 second	Interpretation for Receive Direction	Interpretation for Send Direction	
G.724 [13] G.733 [14] G.762 [15] G.794 [16] 1544					Uses G.704 [10]/G.706 [9] – see appropriate entry in Table 5/M.2100.
G.734 [17] 1544	FAS RAI bit	≥ 1 LOF ≥ 1 LOS ≥ 1 errored FAS ≥ 8 frame bit errors ≥ *g* RAI bits (*g* is US)	ES + SES ES + SES ES ES + SES –	– – – – ES + SES	
G.732 [18] G.735 [19] G.736 [20] G.737 [21] G.738 [22] G.739 [23] G.761 [24] G.793 [25] 2048					Uses G.704 [10]/G.706 [9] – see appropriate entry in Table 5/M.2100.

US Under study.

RAI Remote alarm indication.

TABLE 7/M.2100

In-service ES and SES parameter evaluation criteria for equipment which operates at the secondary level

Equip. Rec. and Path level (kbit/s)	Path overhead available to derive anomaly/defect information	ES/SES Parameter Measurement Criteria (Anomalies and Defects in 1 second)			Remarks
		Anomalies and defects in 1 second	Interpretation for Receive Direction	Interpretation for Send Direction	
G.743 [26] 6312	FAS RAI bit (if equipped)	≥ 1 LOF ≥ 1 LOS ≥ 1 errored FAS ≥ *h* frame bit errors (*h* is US; 43 frame bit errors is suggested) ≥ *i* RAI bits (*i* is US)	ES + SES ES + SES ES ES + SES –	– – – – ES + SES	Send ES resolution limited to part of SES population (if RAI equipped).
G.747 [27] 6312	Parity bit FAS RAI bit	≥ 1 LOF ≥ 1 LOS ≥ 1 Parity error, or ≥ 1 errored FAS ≥ *j* Parity errors, or ≥ *k* frame bit errors (*j* & *k* are US; *j* = 3056 Parity errors, or *k* = 67 frame bit errors are suggested) ≥ *l* RAI bits (*l* is US)	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 US. Send ES resolution limited to part of SES population.
G.742 [28] 8448	FAS RAI bit	≥ 1 LOF ≥ 1 LOS ≥ 1 errored FAS ≥ *m* frame bit errors (*m* is US; 99 frame bit errors are suggested) ≥ *n* RAI bits (*n* is US)	ES + SES ES + SES ES ES + SES –	– – – – ES + SES	Send ES resolution limited to part of SES population.
G.745 [29] 8448	FAS RAI bit	≥ 1 LOF ≥ 1 LOS ≥ 1 errored FAS ≥ *o* frame bit errors (*o* is US; 64 frame bit errors are suggested) ≥ *p* RAI bits (*p* is US)	ES + SES ES + SES ES ES + SES –	– – – – ES + SES	Send ES resolution limited to part of SES population.

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RAI Remote alarm indication

TABLE 8/M.2100

In-service ES and SES parameter evaluation criteria for equipment which operates at the tertiary level

Equip. Rec. and Path level (kbit/s)	Path overhead available to derive anomaly/defect information	ES/SES Parameter Measurement Criteria (Anomalies and Defects in 1 second)			Remarks
		Anomalies and defects in 1 second	Interpretation for Receive Direction	Interpretation for Send Direction	
G.752 [30] 32064	FAS RAI bit	≥ 1 LOF ≥ 1 LOS ≥ 1 1 errored FAS ≥ *q* frame bit errors (*q* is US; 166 frame bit errors are suggested) ≥ *r* RAI bits (*r* is US)	ES + SES ES + SES ES ES + SES –	– – – – ES + SES	Send ES resolution limited to part of SES population.
G.751 [31] 34368	FAS RAI bit	≥ 1 LOF ≥ 1 LOS ≥ 1 errored FAS ≥ *s* frame bit errors (*s* is US; 223 frame bit errors are suggested) ≥ *t* RAI bits (*t* is US)	ES + SES ES + SES ES ES + SES –	– – – – ES + SES	Send ES resolution limited to part of SES population.
G.753 [32] 34368	FAS RAI bit	≥ 1 LOF ≥ 1 LOS ≥ 1 errored FAS ≥ *u* frame bit errors (*u* is US; 191 frame bit errors are suggested) ≥ *v* RAI bits (*v* is US)	ES + SES ES + SES ES ES + SES –	– – – – ES + SES	Send ES resolution limited to part of SES population.
G.752 [30] 44736	Parity bits FAS RAI bit (if equipped)	≥ 1 LOF ≥ 1 LOS ≥ 1 Parity error, or ≥ 1 errored FAS ≥ *w* Parity errors, or ≥ *x* frame bit errors (*w* and *x* are US; *w* = 4698 Parity errors, or *x* = 263 frame bits errors are suggested) ≥ *y* RAI bits (*y* is US)	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 US. Send ES resolution limited to part of SES population (if RAI equipped).

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RAI Remote alarm indication

TABLE 9/M.2100

In-service ES and SES parameter evaluation criteria for equipment which operates at the quaternary level

Equip. Rec. and Path level (kbit/s)	Path overhead available to derive anomaly/defect information	ES/SES Parameter Measurement Criteria (Anomalies and Defects in 1 second)			Remarks
		Anomalies and defects in 1 second	Interpretation for Receive Direction	Interpretation for Send Direction	
G.752 [30] 97728	Parity bit FAS RAI bit	≥ 1 LOF	ES + SES	–	The method of using Parity and/or errored FAS for receive ES and SES evaluation is US. Send ES resolution limited to part of SES population.
		≥ 1 LOS	ES + SES	–	
		≥ 1 Parity error, or	ES	–	
		≥ 1 errored FAS	ES	–	
		≥ *z* Parity errors, or	ES + SES	–	
		≥ *aa* frame bit errors (*z* and *aa* are US; *z* = 38 171 Parity errors or *aa* = 508 frame bit errors are suggested)	ES + SES	–	
		≥ *bb* RAI bits (*bb* is US)	–	ES + SES	
G.751 [31] 139 264	FAS RAI bit	≥ 1 LOF	ES + SES	–	Send ES resolution limited to part of SES population.
		≥ 1 LOS	ES + SES	–	
		≥ 1 errored FAS	ES	–	
		≥ *cc* frame bit errors (*cc* is US; 568 frame bit errors are suggested)	ES + SES	–	
		≥ *dd* RAI bits (*dd* is US)	–	ES + SES	
G.754 [33] 139 264	FAS RAI bit	≥ 1 LOF	ES + SES	–	Send ES resolution limited to part of SES population.
		≥ 1 LOS	ES + SES	–	
		≥ 1 errored FAS	ES	–	
		≥ *ee* frame bit errors (*ee* is US; 637 frame bit errors are suggested)	ES + SES	–	
		≥ *ff* RAI bits (*ff* is US)	–	ES + SES	
G.755 [34] 139 264	Parity bit FAS RAI bit	≥ 1 LOF	ES + SES	–	The method of using Parity and/or errored FAS for receive ES and SES evaluation is US. Send ES resolution limited to part of SES population.
		≥ 1 LOS	ES + SES	–	
		≥ 1 Parity error, or	ES	–	
		≥ 1 errored FAS	ES	–	
		≥ *gg* Parity errors, or	ES + SES	–	
		≥ *hh* frame bit errors (*gg* and *hh* are US; *gg* = 62 151 Parity errors or *hh* = 1742 frame bit errors are suggested)	ES + SES	–	
		≥ *ii* RAI bits (*ii* is US)	–	ES + SES	

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RAI Remote alarm indication

2.5.4.2 *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 § 2.5.3.2).

2.5.4.3 *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 § 2.5.3.3).

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 Series-O Recommendations.

2.5.4.4 *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;

SES – a 1-second period with an integrated BER of $>10^{-3}$.

If, in addition, the test equipment uses a PRBS that is embedded in a standardized path signal then the further ES/SES evaluation criteria referenced in § 2.5.3.5 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 information which can be taken into account are:

Anomalies – interface code violations (per Recommendation G.703 [8]);

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.

2.5.5 *Evaluation of ES and SES parameters from the in-service anomaly and defect information relevant to standardized path signals*

This section shows what anomaly and defect event indicators are available at the various network levels, and shows how these may then be processed into ES and SES parameters. This section is presented as explanatory text followed by tables. The explanatory text is split into six sections which refer to their respective columns. The tables are all of the same format, each table referring to one level as follows:

- Table 4/M.2100: sub-primary level (64 kbit/s);
- Table 5/M.2100: primary level frame (1544, 2048 kbit/s);
- Table 6/M.2100: primary level equipment (1544, 2048 kbit/s);
- Table 7/M.2100: secondary level equipment (6312, 8448 kbit/s);
- Table 8/M.2100: tertiary level equipment (32 064, 34 368, 44 736 kbit/s);
- Table 9/M.2100: quaternary level equipment (97 728, 139 264 kbit/s).

Tables, 4/M.2100 to 9/M.2100 provide guidance for mapping the wide variety of path overhead and the line signal anomaly and defect indicators into the standard ES and SES parameters. Tables have been prepared for each network level, from 64 kbit/s sub-primary rate to the 97 728/139 264 kbit/s quarternary rate. Each table contains six columns.

2.5.5.1 *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.

2.5.5.2 *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 alarm indication events;
- A-bits – Remote alarm indication – Bit-3 in Recommendation G.704 [10];
- Parity bits;
- S-bits – (multi)frame alignment signal for 1544 kbit/s signals.

2.5.5.3 *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 alarm indication – Bit-3 – Recommendation G.704 [10];

– Remote alarm 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 Recommendation G.822 [2]). 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 § 2.5.3.2) and should be interpreted as causing an ES (but not an SES).

2.5.5.4 *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.

2.5.5.5 *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.

2.5.5.6 *Column 6: Remarks*

This column provides further explanatory text.

2.6 *Performance limits for bringing into service 64 kbit/s and primary rate paths*

This section defines the methodology of calculation of BIS performance limits for international primary rate paths and the corresponding values.

The BIS testing procedure, including how to deal with any period of unavailability during the test, is defined in Recommendation M.2110 [42], § 4.2.

2.6.1 *Calculation of the 24-hour BIS limits*

The 24-hour BIS limits S1 and S2 for each parameter (ES and SES) are calculated on the basis of the BIS objective, which is fixed at two times better than the RPO.

The RPO is determined by summing the allocation in per cent for all path sections in the path (see Annex A). When modifications are made to one or more individual sections, the new allocation must be summed as a per cent to obtain the overall path RPO.

The BIS objective, S1 and S2 are then derived from the overall RPO. Values for the BIS objective, S1 and S2 should not be summed for the individual sections to determine end-to-end limits in order to avoid the introduction of errors due to

– the inherent non-linearity of S1 and S2 values; and,

– cumulative rounding errors in BIS objective, S1 and S2.

BIS objective, S1 and S2 are calculated as follows:

BIS objective = RPO/2

S1 = RPO/2 – D

S2 = RPO/2 + D

where

$$RPO = A \times 86\,400 \times PO$$

and D is derived from a pragmatic rule and described by the formula

$$2 \times \sqrt{BIS\ objective}$$

A is the Path Allocation (see § 2.3/M.2100),

86 400 is the Number of seconds in 24 hours,

PO is the Performance Objective: 4% for ES, 0.1% for SES (see Table 1/M.2100).

2.6.2 *BIS limits for 64 kbit/s and primary rate paths*

Performance limits for BIS are given in Table 10/M.2100, where values of S1 and S2 are calculated according to the path allocation and the testing duration. The limits S1 and S2 are rounded to the nearest integer value.

2.6.3 *The calculation of the seven-day BIS limits*

Under some cases, described in Recommendation M.2110 [42], a supplementary test over seven days is necessary and performance must satisfy the BIS objective on seven days, for each parameter (ES and SES). It is obtained by multiplying the BIS objective for one day with the value 7.

Table 10/M.2100 gives the values relative to BIS objective for seven days for various path allocations.

2.7 *Performance limits for maintenance*

Once entities have been placed into service, the supervision of the network requires additional limits, as described in Recommendation M.20 [37]. The supervision process involves analysing anomalies and defects detected by maintenance entities to determine the performance level.

The maintenance procedures are defined in Recommendation M.2120 [41], and the use of thresholds is described in § 2.4.5.

2.7.1 *Types of thresholds*

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

2.7.1.1 *Thresholds based on a T1 evaluation period*

The monitoring duration T1 is fixed to a 15-minute value and ES and SES are counted over this period.

The values for 15-minute maintenance limits are pragmatic values.

A threshold report occurs when an ES or SES threshold is 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 Recommendation M.2120 [41], § 2.3.

TABLE 10/M.2100

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

	ES (4%) 1 day				ES 7 days	SES (0.1%) 1 day				SES 7 days
Path allocation (%)	RPO	BIS objective	S1	S2	BIS objective	RPO	BIS objective	S1	S2	BIS objective
0.5	17	9	3	15	60	0	0	0	1	2
1.0	35	17	9	26	121	1	0	0	2	3
1.5	52	26	16	36	181	1	1	0	2	5
2.0	69	35	23	46	242	2	1	0	3	6
2.5	86	43	30	56	302	2	1	0	3	8
3.0	104	52	37	66	363	3	1	0	4	9
3.5	121	60	45	76	423	3	2	0	4	11
4.0	138	69	52	86	484	3	2	0	4	12
4.5	156	78	60	95	544	4	2	0	5	14
5.0	173	88	68	105	605	4	2	0	5	15
5.5	190	95	76	115	665	5	2	0	5	17
6.0	207	104	83	124	726	5	3	0	6	18
6.5	225	112	91	134	786	6	3	0	6	20
7.0	242	121	99	143	847	6	3	0	7	21
7.5	259	130	107	152	907	6	3	0	7	23
8.0	276	138	115	162	968	7	3	0	7	24
8.5	294	147	123	171	1028	7	4	0	8	26
9.0	311	156	131	180	1089	8	4	0	8	27
9.5	328	164	139	190	1149	8	4	0	8	29
10.0	346	173	147	199	1210	9	4	0	8	30
10.5	363	181	155	208	1270	9	5	0	9	32
11.0	380	190	163	218	1331	10	5	0	9	33
11.5	397	199	171	227	1391	10	5	1	9	35
12.0	415	207	179	236	1452	10	5	1	10	36
12.5	432	216	187	245	1512	11	5	1	10	38
13.0	449	225	195	255	1572	11	6	1	10	39
13.5	467	233	203	264	1633	12	6	1	11	41
14.0	484	242	211	273	1693	12	6	1	11	42
14.5	501	251	219	282	1754	13	6	1	11	44
15.0	518	259	227	291	1814	13	6	1	12	45
15.5	536	268	235	301	1875	13	7	2	12	47
16.0	553	276	243	310	1935	14	7	2	12	48
16.5	570	285	251	319	1996	14	7	2	12	50
17.0	588	294	259	328	2056	15	7	2	13	51
17.5	605	302	268	337	2117	15	8	2	13	53
18.0	622	311	276	346	2177	16	8	2	13	54
18.5	639	320	284	355	2238	16	8	2	14	56
19.0	657	328	292	365	2298	16	8	2	14	57
19.5	674	337	300	374	2359	17	8	3	14	59
20.0	691	346	308	383	2419	17	9	3	15	60
20.5	708	354	317	392	2480	18	9	3	15	62
21.0	726	363	325	401	2540	18	9	3	15	64
21.5	743	372	333	410	2601	19	9	3	15	65
22.0	760	380	341	419	2661	19	10	3	16	67
22.5	778	389	349	428	2722	19	10	3	16	68
23.0	795	397	358	437	2782	20	10	4	16	70
23.5	812	406	366	446	2843	20	10	4	17	71

TABLE 10/M.2100 (*cont.*)

Values for bringing-into service limits for international digital paths

	ES (4%) 1 day				ES 7 days	SES (0.1%) 1 day				SES 7 days
Path allocation (%)	RPO	BIS objective	S1	S2	BIS objective	RPO	BIS objective	S1	S2	BIS objective
24.0	829	415	374	455	2903	21	10	4	17	73
24.5	847	423	382	465	2964	21	11	4	17	74
25.0	864	432	390	474	3024	22	11	4	17	76
25.5	881	441	399	483	3084	22	11	4	18	77
26.0	899	449	407	492	3145	22	11	5	18	79
26.5	916	458	415	501	3205	23	11	5	18	80
27.0	933	467	423	510	3266	23	12	5	18	82
27.5	950	475	432	519	3326	24	12	5	19	83
28.0	968	484	440	528	3387	24	12	5	19	85
28.5	985	492	448	537	3447	25	12	5	19	86
29.0	1002	501	456	546	3508	25	13	5	20	88
29.5	1020	510	465	555	3568	25	13	6	20	89
30.0	1037	518	473	564	3629	26	13	6	20	91
30.5	1054	527	481	573	3689	26	13	6	20	92
31.0	1071	536	489	582	3750	27	13	6	21	94
31.5	1089	544	498	591	3810	27	14	6	21	95
32.0	1106	553	506	600	3871	28	14	6	21	97
32.5	1123	562	514	609	3931	28	14	7	22	98
33.0	1140	570	522	618	3992	29	14	7	22	100
33.5	1158	579	531	627	4052	29	14	7	22	101
34.0	1175	588	539	636	4113	29	15	7	22	103
34.5	1192	596	547	645	4173	30	15	7	23	104
35.0	1210	605	556	654	4234	30	15	7	23	106
35.5	1227	613	564	663	4294	31	15	8	23	107
36.0	1244	622	572	672	4355	31	16	8	23	109
36.5	1261	631	580	681	4415	32	16	8	24	110
37.0	1279	639	589	690	4476	32	16	8	24	112
37.5	1296	648	597	699	4536	32	16	8	24	113
38.0	1313	657	605	708	4596	33	16	8	25	115
38.5	1331	665	614	717	4657	33	17	8	25	116
39.0	1348	674	622	726	4717	34	17	9	25	118
39.5	1365	683	630	735	4778	34	17	9	25	119
40.0	1382	691	639	744	4838	35	17	9	26	121

Note – Refer to §§ 2.6.1., 2.6.2 and 2.6.3 for guidance in using the values in this table.

2.7.1.2 *Thresholds based on a T2 evaluation period*

The monitoring duration T2 is fixed to a 24-hour value.

A threshold report occurs when an ES or SES threshold is exceeded over the period of time T2 as explained in Recommendation M.2120 [41].

2.7.2 *Threshold values*

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

The default thresholds for the 15-minute window of an international path are given in Table 11/M.2100 for various allocations. Thresholds for the 24-hour window are under study.

TABLE 11/M.2100

Values for maintenance limits for international primary rate digital paths

	15-minute Threshold		15-minute Reset Threshold (optional)	
Path Allocation (%)	ES	SES	ES	SES
0.5 → 2.5	120	15	0	0
3 → 4.0	120	15	1	0
4.5 → 7.0	120	15	2	0
7.5 → 10.0	120	15	3	0
10.5 → 11.0	120	15	4	0
11.5 → 13.0	150	15	4	0
13.5 → 15.5	150	15	5	0
16.0 → 18.5	150	15	6	0
19.0 → 20.0	150	15	7	0
20.5 → 21.5	180	15	7	0
22.0 → 24.5	180	15	8	0
25.0 → 27.0	180	15	9	0
27.5 → 30.0	180	15	10	0
30.5 → 33.0	180	15	11	0
33.5 → 36.0	180	15	12	0
36.5 → 40.0	180	15	13	0

2.8 *Long-term quality monitoring/measurement*

Performance monitoring history should be kept for at least one year (provisional value).

3 Error performance for the PDH nth rate

Under study.

4 Timing 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 fulfill the requirements of Recommendation G.822 [2].
- The second one, called jitter and wander, is related to the fluctuations in the timing signal. Limits for jitter and wander are defined in Recommendations G.823 [35] and G.824 [36]. 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.

5 Availability at 64 kbit/s layer and higher bit rate

5.1 *Definitions of available and unavailable states*

5.1.1 *64 kbit/s*

When in the available state, a transition to the unavailable state is declared when ten consecutive SES are observed; these ten seconds are considered to be part of the unavailable time.

When in the unavailable state, a transition to the available state is declared when ten consecutive non-SESs are observed; these ten seconds are considered to be part of the available time.

5.1.2 *Primary rate*

Path unavailable seconds is a count of one second intervals for which the path is unavailable. The path is said to be unavailable at the onset of P consecutive SES (or a failure condition for the 1.5 Mbit/s hierarchy). Once unavailable, the path becomes available at the onset of Q consecutive seconds with no SES. In computing the unavailable second parameter the initial P second transition period is included, while the final Q-second transition period is not.

Inclusion of AIS and LOF fault conditions in the unavailable second parameter is achieved by a logical OR of these conditions with the above noted consecutive SES. In computing the resulting unavailable seconds parameter the initial time (seconds) to detect the fault is included, while the final time (seconds) to clear the fault is not.

The value of P and Q should be less than or equal to 10 seconds.

5.1.3 *Higher bit rates*

Under study.

5.2 *Inhibiting performance monitoring during unavailable time (and fault conditions)*

Figure 5/M.2100 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 signal condition and shows momentary, and persistent conditions. The second row indicates if an error condition exists (Y) or not (N). Error conditions include anomalies, defects, or faults as shown in Figure 5/M.2100. The third row indicates whether the path has failed (Y or N). Proceeding in a similar manner, by reading down then across, are shown the actual and adjusted path unavailable seconds and parameter counts (e.g. ES and SES). The solid time lines for each of these latter three rows indicate the procedures for calculating path unavailable seconds, real-time and adjusted real-time parameter counts, when referenced to the vertical dotted lines in the original signal condition.

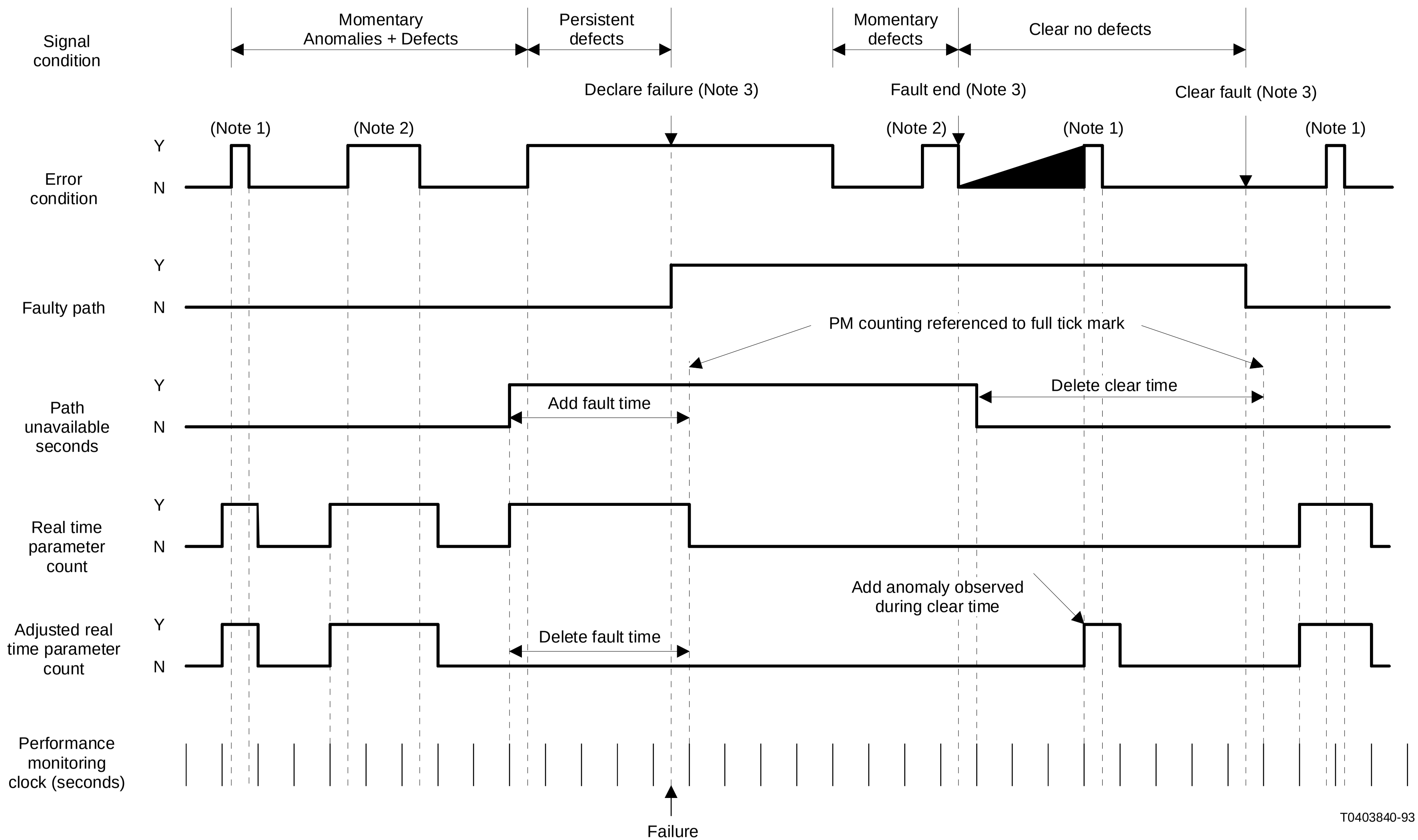
Three events, Declaration of a Failure, End of a Fault, and the Clearing of a Fault, are recorded in time to show

- the timing of failure declaration, fault end and fault clearing;
- to account for the persistent occurrence of defect events leading to the fault and the absence of defect events during the clearing period;
- the correction to the unavailable second counter;
- the rules for deleting and adding increments in time in the unavailable second counter, the time taken to clear, and the time added to the unavailable second counter respectively that represents that portion of the persistent error condition leading up to the declaration of failure;
- the count of anomalies during the clearing time interval.

Note that the signal condition transition, or declaration instant is independent of the performance monitoring clock one-second boundaries. This is evident by observing the placement of these instants (vertical dotted lines) in relation to the one-second timing marks.

5.3 *Unavailability limits*

For the time being unavailability limits are left for negotiation. This subject is under consideration.



Note 1 – Anomaly (or anomalies).

Note 2 – Defect (or defects).

Note 3 – Declaration of failure events is independent of performance monitoring time clock one second boundaries.

FIGURE 5/M.2100

Illustration of performance monitoring inhibiting during unavailable time and failure conditions

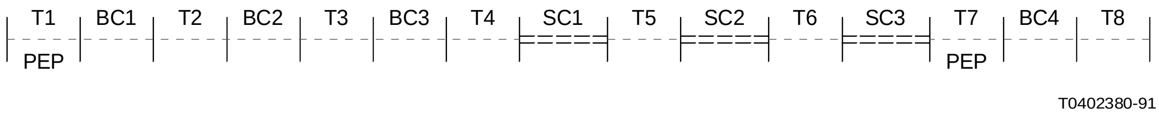
ANNEX A

(to Recommendation M.2100)

Example applications of RPO allocation from Table 2/M.2100

This Annex provides two examples showing the application of RPO Allocation Table described in § 2.3. The first example is of a primary rate path which is extremely long and as such does not allow for additional tandem paths to extend the 64 kbit/s path. The second example is of a complex network where a 64 kbit/s path is routed over three tandem primary rate paths. The purpose of these examples is to show clearly 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 path so that the high grade international allocation of 40% is not exceeded.

Example 1



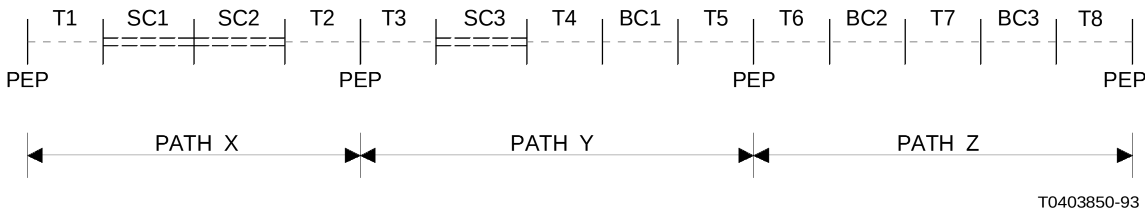
T	Terminating or transit IPCE		
BC	Border crossing ICPCE		
SC	Submarine cable ICPCE		
T1, T8	IPCE (Terminating)	1000 km-2500 km	2 × 4.0% = 8.0%
T2-T5	IPCE (Transit)	500 km-1000 km	4 × 3.0% = 12.0%
T6	IPCE (Transit)	< 500 km	1 × 2.0% = 2.0%
T7	IPCE (Transit)	> 5000 km	1 × 8.0% = 8.0%
SC1-SC3	ICPCE (Optical 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%

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

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

The total international high grade allocation for a 64 kbits/s path 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.

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)	500-1000 km	1 × 3.0% = 3.0%
T7	IPCE (Transit)	1000-2500 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%

References:

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[5] CCITT Recommendation G.707 *Synchronous digital hierarchy bit rates.*

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[7] CCITT Recommendation G.709 *Synchronous multiplexing structure.*

[8] CCITT Recommendation G.703 *Physical/electrical characteristics of hierarchical digital interfaces.*

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[12] CCITT Recommendation H.221 *Frame structure for a 64 kbit/s channel in audiovisual teleservices*.

[13] CCITT Recommendation G.724 *Characteristics of a 48-channel low bit rate encoding primary multiplex operating at 1544 kbit/s*.

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[21] CCITT Recommendation G.737 *Characteristics of an external access equipment operating at 2048 kbit/s offering synchronous digital access at 384 kbit/s and/or 64 kbit/s*.

[22] CCITT Recommendation G.738 *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*.

[23] CCITT Recommendation G.739 *Characteristics of an external access equipment operating at 2048 kbit/s offering synchronous digital access at 320 kbit/s and/or 64 kbit/s*.

[24] CCITT Recommendation G.761 *General characteristics of a 60-channel transcoder equipment*.

[25] CCITT Recommendation G.793 *Characteristics of 60-channel transmultiplexing equipment*.

[26] CCITT Recommendation G.743 *Second order digital multiplex equipment operating at 6312 kbit/s and using positive justification*.

[27] CCITT Recommendation G.747 *Second order digital multiplex equipment operating at 6312 kbit/s and multiplexing three tributaries at 2048 kbit/s*.

[28] CCITT Recommendation G.742 *Second order digital multiplex equipment operating at 8448 kbit/s and using positive justification*.

[29] CCITT Recommendation G.745 *Second order digital multiplex equipment operating at 8448 kbit/s and using positive/zero/negative justification*.

[30] CCITT Recommendation G.752 *Characteristics of digital multiplex equipments based on a second order bit rate of 6312 kbit/s and using positive justification.*

[31] CCITT Recommendation G.751 *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.*

[32] CCITT Recommendation G.753 *Third order digital multiplex equipment operating at 34 368 kbit/s and using positive/zero/negative justification*.

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