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PERFORMANCE LIMITS FOR BRINGING INTO SERVICE AND MAINTENANCE OF DIGITAL PATHS, SECTIONS, AND LINE SECTIONS

Reedition of CCITT Recommendation M.550 published in the Blue Book, Fascicle IV.1 (1988)

NOTES

1 CCITT Recommendation M.550 was published in Fascicle IV.1 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

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

Recommendation M.550

PERFORMANCE LIMITS FOR BRINGING INTO SERVICE AND MAINTENANCE OF DIGITAL PATHS, SECTIONS, AND LINE SECTIONS

1 General

The purpose of this Recommendation is to provide limits for bringing into service, and limits for maintenance of digital paths, sections, and line sections in order to achieve the performance objectives given for ISDN in the Series G Recommendations. These objectives include error performance (Rec. G.821 [1]), slips (Rec. G.822 [2]), jitter and wander (Rec. G.823 [3] and Rec. G.824 [4]), and availability. This Recommendation presently only contains limits for error performance. The other limits are under study. This Recommendation describes the parameters to be mesured and the measurement techniques to be employed to meet the principles given in Recommendations M.20, M.32 and M.34.

The methods and procedures for applying these limits are described in Recommendation M.555 for the bringing into service procedures.

Since the performance limits are intended to satisfy the needs of the future digital network, it must be recognized that such limits cannot be readily achieved by all of today's digital equipment and systems. Nonetheless, it is intended that there will be a single set of limits that applies to all technologies.

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.

This Recommendation covers all digital paths, sections, and line sections which operate at 64 kbit/s and higher, including the ISDN subscriber access described in Recommendation I.412 [5], and the network digital hierarchy described in Recommendation G.702 [6].

There is a need to reduce measured data to that which is essential and relevant to maintenance staff.

2 Allocation of objectives

Digital error performance objectives on which this Recommendation is based are given in Recommendation G.821 [1] for an end-to-end 64 kbit/s hypothetical reference connection (HRX) defined in Recommendation G.801 [7]. These objectives are further allocated in Recommendation G.821 [1] to local, medium, and high grade parts of the connection. However, maintenance limits are needed for smaller entities. Hence, a further allocation is necessary, so that limits can be developed for digital paths, digital sections, and digital line sections, as these are defined in Recommendation M.300. Following are described the reference models to be used when allocating the digital performance objectives on which bringing into service and maintenance limits will be based.

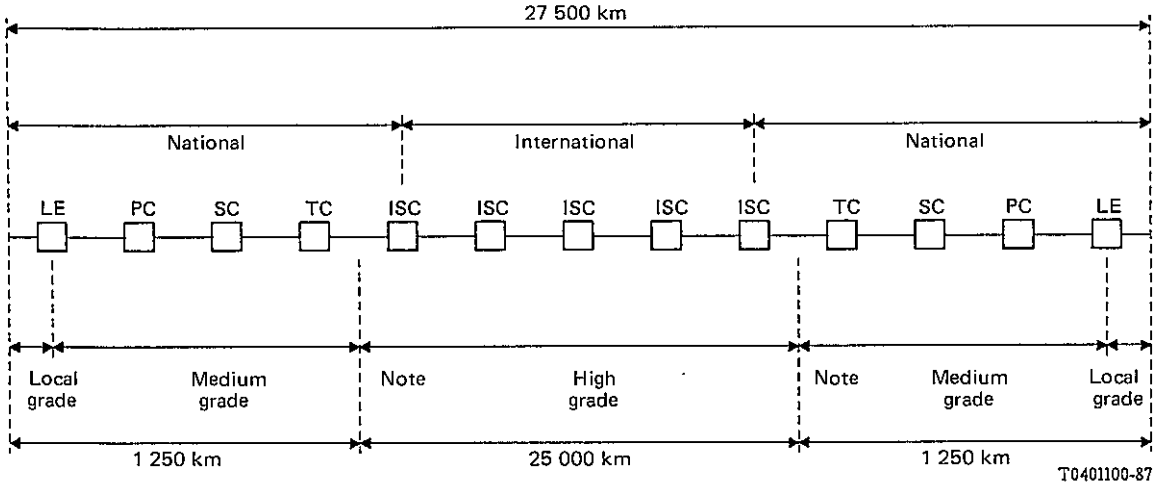
2.1 *Reference models*

The HRX of Recommendation G.801 [7] and the circuit quality demarcation of Recommendation G.821 [1] are shown combined in Figure 1/M.550.

The error performance objectives for this 64 kbit/s connection are given in Table 1/M.550.

Half of the overall severely errored seconds, (SES) objective of 0.2% is reserved as a block allocation to accommodate adverse network conditions (e.g. for digital radio systems) so the values in Table 2/M.550 apply to the remaining 0.1% SES. These overall objectives are further allocated to the circuit quality classifications of the HRX as shown in Table 2/M.550.

For Recommendation G.921 [8], a further allocation of objectives to hypothetical reference digital sections (HRDS) based on the 2.048 Mbit/s hierarchy is shown in Table 3/M.550. An HRDS is a digital line section in the terminology of Recommendation M.300.



Note – The exact boundary between medium and high grade circuit quality classification, which always occurs at an exchange, cannot be specified, since the 1250 km allowed for medium grade may not cover the entire distance from the local exchange to the international switching centre in large countries.

FIGURE 1/M.550

HRX and circuit quality demarcation

TABLE 1/M.550

Error performance objectives

Performance classification	Objective (maximum % of time)
Degraded minutes (DM)	10.
Severely errored seconds (SES)	0.2
Errored seconds (ES)	8.

TABLE 2/M.550

Allocation of objectives

HRX circuit quality classification	Percentage of objective
Local (each end)	15
Medium (each end)	15
High	40

TABLE 3/M.550

Digital line section quality classificaton for error performance

Section quality class	HRDS length (km)	Allocation (%)	For circuit class
1	280	0.45	High or medium
2	280	2.45	Medium
3	50	2.45	Medium
4	50	5.45	Medium

The allocation is a percentage of the overall objective for the HRX for Errored Seconds (ES), SES, and Degrated Minutes (DM). For shorter sections, there is no reduction in the allocation. For a longer section, its overall allocation should correspond to that of an integer number of HRDSs, the combined length of which is at least as long as the real section.

These figures and tables are simplified versions of those in Recommendations G.801 [7], G.821 [1], and G.921 [8]. For a full explanation, the original figures and tables, along with their footnotes, should be consulted.

The comparable allocations for the 1.5 Mbit/s hierarchy is under study in Recommendation G.911 [9].

2.2 *Allocation principles to be employed*

For this Recommendation, the allocation of the error performance objectives for each digital path, digital section and digital line section, as defined in Recommendation M.300, must be determined. This will be based on the allocation for the different parts of the HRX as defined in Recommendation G.821 [1], and on the allocations for digital line sections as defined in Recommendations G.911 [9] and G.921 [8].

The allocation principles for satellites are for further study, taking into account Recommendation G.821 [1].

The significant performance degradation of radio-relay systems tend to be concentrated into a few days or even hours (those times with severe fading). For this reason, a direct linear derivation of performance limits for shorter time periods from Recommendation G.821 [1] monthly performance objectives may not be suitable for digital sections containing radio-relay systems.

The effect of fluctuations that occur in radio-relay system performance, as well as to a lesser degree in other transmission media, requires further study to set appropriate bringing into service limits, maintenance limits and test durations.

2.2.1 *Allocation principles for sections*

The objectives to be used for digital line sections can be taken directly from Recommendations G.911 [9] and G.921 [8].

However, digital sections and digital paths are achieved by interconnections of digital line sections and multiplexing equipment at various hierarchical levels (8, 34, 45, 140 Mbit/s).

The performance allocation for digital sections is the sum of the allocations of the digital line sections from which the digital section is derived.

2.2.2 *Allocation principles for digital paths*

The allocation principles for the paths differ for bringing into service and for maintenance.

For bringing into service, the allocation is the same as that for digital sections, namely the sum of the allocations of the digital line sections from which the path is derived. This results in an allocation based on the real physical configuration of the path. If the performance objective for a path is denoted *A*, then:

$$A = \sum_j N_j \cdot Q_j$$

where

N_j Number of digital line sections of quality class *j*,

Q_j Allocation for a digital line section of quality class *j*.

For maintenance allocation, to minimize the number of thresholds that must be monitored in the exchange, a different objective is used, namely the maximum allowed allocation for the type of path. This allocation is determined by the class of exchange at each end of the path. The allocation principle is illustrated by the following example.

If the nominal section of Figure 1/M.550 is made up of the 1250 km medium grade allocation, the medium grade path allocations can be defined as:

A = Allocation for path LE-PC (local exchange-primary centre)

B = Allocation for path PC-SC (primary centre-secondary centre)

C = Allocation for path SC-TC (primary centre-tertiary centre)

D = Allocation for path TC-ISC (tertiary centre-international switching centre)

Further, let

W_i = Number of digital sections of class 1 (allocation 0.45%)

X_i = Number of digital sections of class 2 (allocation 2%)

Y_i = Number of digital sections of class 3 (allocation 2%)

Z_i = Number of digital sections of class 4 (allocation 5%)

where subscript *i* denotes the paths LE-PC (denoted as *a*), PC-SC (denoted as *b*), etc. with allocations *A*, *B*, etc., as defined above.

To meet the Recommendation G.821 [1] objectives, each Administration must jointly determine *A* to *D* and W_i to Z_i based on its transmission plan and on its network design in order to meet the equations below:

$$A + B + C + D \leq 15\%$$

$$A \geq 0.45\,W_a + 2.0\,X_a + 2.0\,Y_a + 5.0\,Z_a$$

$$B \geq 0.45\,W_b + 2.0\,X_b + 2.0\,Y_b + 5.0\,Z_b$$

$$C \geq 0.45\,W_c + 2.0\,X_c + 2.0\,Y_c + 5.0\,Z_c$$

$$D \geq 0.45\,W_d + 2.0\,X_d + 2.0\,Y_d + 5.0\,Z_d$$

For example, if the paths between the LE and PC in this Administration's network in the worst case are made up of two line sections of class 2 and one of class 3, then *A* must be 2 × 2% + 1 × 2% = 6%. Thus, $B + C + D$ must be ≤ 9%. Similarly, values of *B* to *D* can be selected.

3 Relationship between performance limits and objectives

3.1 *Relationship between short-term limits and long-term objectives*

The limits in this Recommendation are to be used to indicate the need for actions during the phases of maintenance and bringing into service. These procedures are intended to result in network performance which meets the performance objectives of the relevant Series G 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 bringing-into-service limits be based on shorter measurement intervals.

Statistical fluctuations in the occurrence of anomalous events in time 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 must be set to ensure that passing the tests will predict, with an acceptable level of confidence, that the long-term objectives will be met. The limits and durations given as examples below were arrived at after comparing limits derived from statistical theory to empirically observed network performance.

3.2 *Types of limits*

Limits are needed for several maintenance functions as defined in Recommendation M.20. This Recommendation provides limits for three of these functions: bringing into service, keeping the network operational (called maintenance here) and system restoration. Limits for commissioning (installation and acceptance testing) are not provided in CCITT Recommendations.

Bringing-into-service tests are rigorously done by measuring using a quasi-random signal source (QRSS) between digital junction interfaces. Due to the statistical character of the degradation in digital networks, these measurements should be long-term measurements. This applies to new equipment or routes. However, for practical reasons (a new path on a route with many paths already in-service, rearrangements of the network, etc.) the measurements between junctions may be reduced to a quick measurement and the supervision completed with performance monitoring equipment.

Two limits are provided for use in bringing-into-service testing. If performance is better than the first limit, the entity can be brought into service without doubt. If performance is between the two limits, further testing is necessary. Corrective action is required if performance is worse than the second limit. The definition of the limits are a function of a given allocation and of the measurement duration and will be based on a predictive model under study. These limits depend on Recommendation G.821 [1] parameters for a given bit rate.

Once entities have been placed into service, supervision of the network requires additional limits, as described in Recommendation 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 than the bringing-into-service limit.

3.2.1 *Reference performance objectives*

The reference performance objectives are defined as the performance objectives for ES, SES, and DM directly derived from Recommendations G.821 [1], G.911 [9] and G.921 [8] using recommended allocations and from the additional allocations described above in § 2 for digital paths, sections and line sections.

Reference performance objectives are calculated on a long-term basis (one month is suggested). These form the basis from which limits for bringing into service and maintenance are set.

3.2.2 *Bringing-into-service limits*

The aging margin is the difference between the reference performance objective and the bringing-into-service limit. This margin should be as large as possible to minimize maintenance interventions.

This margin for digital line sections will depend on the procedures of individual Administrations. A stringent limit which is 10 times better than the reference performance objective and a measuring period of a few days should be used when previous commissioning tests have not been conducted.

When previous commissioning tests have been carried out, the out-of-service test for bringing into service can be conducted for a shorter period and does not require the same stringent limits.

Continuous in-service monitoring is required to provide sufficient confidence in the long-term performance. (Typically, commissioning tests have durations of several days and have more stringent limits than bringing-into-service tests).

The ageing margin for digital sections and paths is on the order of two times better than the reference performance objective. The testing duration will obviously be limited to no more than a few days.

All of these bringing-into-service limits and durations are for further study.

Two limits can be calculated:

– S1, a limit corresponding to a number of events (ES, SES, DM) under which the entity can be brought into service without any doubt;

– S2, a limit corresponding to a number of events above which it is necessary to improve the performance of the entity under test.

For an observed number of events between the values of S1 and S2 the entity may be conditionally be brought into service. It then becomes necessary to monitor the evolution of its performance during a longer period of time. This monitoring can be performed using the TMN surveillance capability. The value of S1 is equal to the bringing-into-service limit described above. The value of S2 can be derived from S1 using a statistical coefficient under study.

3.2.3 *Maintenance limits*

3.2.3.1 *Unacceptable performance limits*

This performance level is defined in Recommendation M.20 (§ 5.1.3).

The unacceptable performance limit for a given entity is at least 10 times worse than the reference performance objective. The monitoring duration is between 15 minutes and one hour.

3.2.3.2 *Degraded performance limits*

This performance level is defined in Recommendation M.20 (§ 5.1.3).

The degraded performance limit for a given entity is on the order of two times better for line sections and 1.3 times better for paths and sections than the reference performance objective. The monitoring duration may be a fixed duration that depends on the rate in the digital hierarchy.

3.2.3.3 *Performance limit after intervention (repair)*

This performance limit is on the order of eight times better than the reference preformance objective for digital line sections and the same as the bringing-into-service limit for digital paths and sections (see Recommendations M.35 and M.555).

3.2.4 *System restoration limits*

The “restoration indication signal” is used to control sytem restoration (under study).

3.3 *Performance limits*

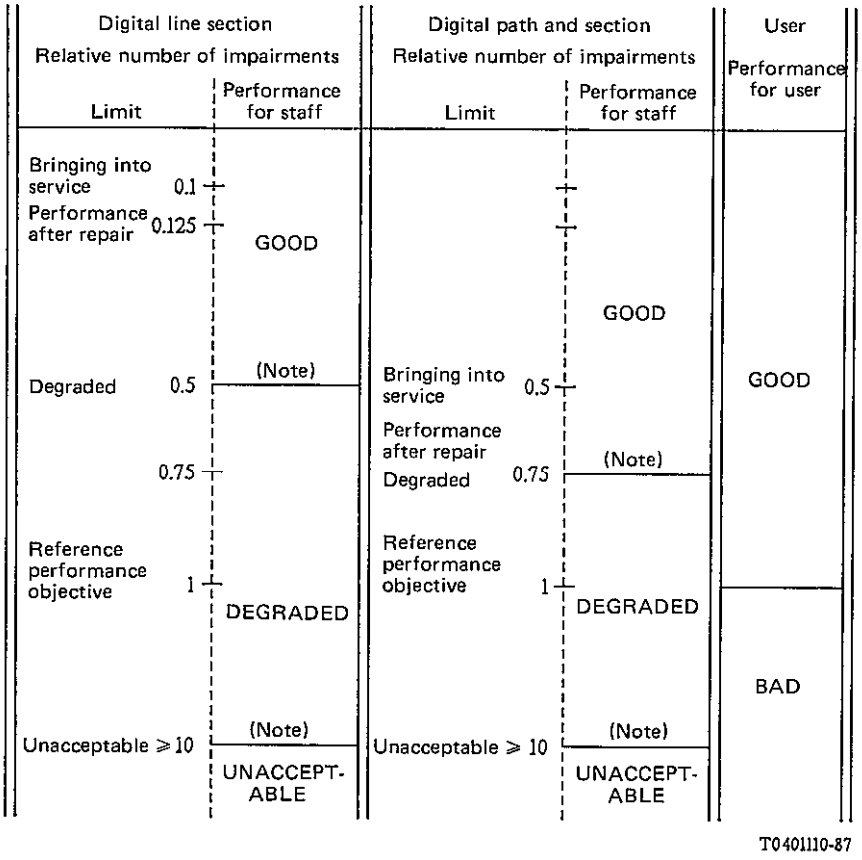
Performance limits are defined for Recommendation G.821 [1] parameters (ES, SES, DM). It is obvious that each performance limit will have its own threshold and will require its own measurement duration. Examples of the above principles and limits are shown in Figure 2/M.550.

3.4 *Translation of performance measurements*

Translation of performance measurements at primary rate and above, to error performance parameters at 64 kbit/s will follow the rules in Annex D of Recommendation G.821 [1].

3.5 *Use of thresholds*

The general strategy for the use of performance monitoring information and thresholds is described in Recommendation M.34. It is expected that 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 level are reached [e.g. prompt maintenance alarm (PMA) or deferred maintenance alarm (DMA)], 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.



Note – When exceeding these limits, the monitoring process should generate input information for the alarm information process (as defined in Rec. M.20).

FIGURE 2/M.550

Example of relative limits

4 Parameters for performance limits

The basic performance parameters to be estimated are ES, SES, and DM as defined in Recommendation G.821 [1]. This allows measurement of the unavailability of digital paths, sections, and line sections and of their performance.

These parameters are measured using the concepts of anomalies and defects defined in Recommendation M.20 as shown in Figure 3/M.550.

4.1 *Basic performance parameters*

The basic performance parameters are the following:

– *Errored seconds* (ES)

An errored second is a second with at least one anomaly or defect.

– *Severely errored seconds* (SES)

A severely errored second is a second with a binary error ratio (BER) [as can be measured using a quasi-random signal source (QRSS)] greater than or equal to 10^{-3} or at least one defect (except slips).

A pseudo-severely errored second is a second with at least N1 anomalies (when the anomaly is not a binary error, i.e. when it is an error indicator such as a code violation, CRC error, etc.) or one defect (except slips). The value of N1 is an estimator defined to correspond to a BER of 10^{-3} in one second. N1 is a function of the accuracy and efficiency of the anomaly detectors.

– *Degraded minutes* (DM)

A degraded minute is a group of 60 consecutive seconds, after excluding SES, with a BER of 10^{-6} or worse.

A pseudo-degraded minute is a group of 60 consecutive seconds, after excluding SES, with at least N2 anomalies or at least one slip (when the anomaly is not a binary error). N2 is calculated similarly to N1, to detect a BER of 10^{-6} in one minute.

Two techniques used to make these measurements are QRSS and performance monitoring.

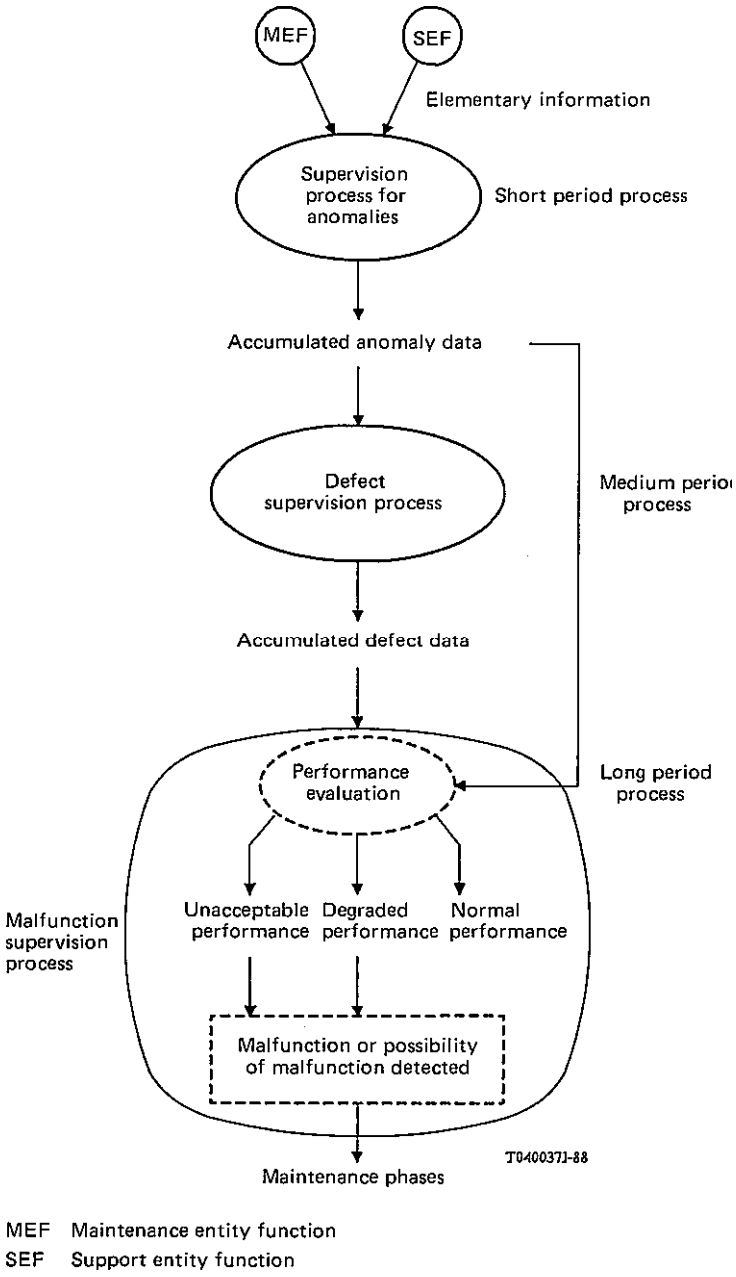


FIGURE 3/M.550

Supervision process for a maintenance entity

4.2 *Measurements using a QRSS*

When a QRSS is used to measure the basic performance for bringing into service or maintenance, the anomalies and defects detected by the measuring equipment are defined below.

4.2.1 *Anomalies*

Bit errors are the only types of anomalies detected by a QRSS measurement.

4.2.2 *Defects*

Loss of signal and loss of synchronization are the types of defects detected by a QRSS measurement.

4.3 *Measurements using performance monitoring*

When performance monitoring is used to estimate the basic performance parameters for maintenance, the anomalies and defects detected by network elements (NEs) are defined below. DM may be calculated in NEs or in an operations system.

4.3.1 *Anomalies*

Anomalies detected by NEs include the following:

a) Bit error indicators:
   - code violations,
   - CRC errors,
   - frame alignment signal errors,
   - block parity errors.

b) Loss of signal energy (possibly brief).

The probability of error detection must be specified for both Poisson and bursty error models. The efficiency (detected errors/actual errors) of the information generated will be taken into account in the establishment of the basic performance parameters.[1]

4.3.2 *Defects*

Defects include the following parameters generated by the equipment:

- loss of frame alignment (or loss of synchronisation);
- loss of signal;
- alarm indication signal (AIS);
- alarm information to the remote end;
- slips;
- restoration indication signal (under study).

Loss of frame alignment is defined in G.704 [10] and AIS and alarm information to the remote end are defined in Recommendation M.20, § 5.4. A string of N_i zeros at bit rate i will be considered a loss of signal. The value of N_i is for further study.

5 Performance limits

Performance limits are expressed by the number of events in the specified time interval, not by the percent of time.

The tables are entered using the percent allocation of the overall objective that applies to the entity in question. These reference performance objectives are defined in § 2. They are calculated as follows:

Reference performance objective = duration × allocation × objective

6 Bringing-into-service and maintenance limits for digital line sections

The particular allocations given in Tables 4/M.550 and 5/M.550 are for the 2 Mbit/s hierarchy. No similar allocations exist for the 1.5 Mbit/s hierarchy.

The duration of the test indicated in the tables is for example only and requires further study. It should be noted that some Administrations use one duration (e.g. on the order of days) for the test of the first digital section in a block and a shorter duration (e.g. on the order of hours) for the remaining sections in that block that are brought into service within a few weeks. The possibility of using shorter test durations in those cases when in-service performance monitoring will be used following the bringing-into-service test is an area for further study.

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[1] Further study is needed to relate these anomalies to the performance parameters specified in Recommendation G.821 [1], taking into account error distributions, e.g. Poisson and bursty, and algorithms for estimating performance parameter values from observed anomalies. This study needs to be coordinated with Working Party IV/2 and with Study Groups XV and XVIII.

TABLE 4/M.550

Bringing-into-service limits for 64 kbit/s digital line sections[a)]

Allocation (%)	Reference performance objective Events/4 days			S1 limit Events/4 days			S2 limit Events/4 days		
	ES	SES	DM	ES	SES	DM	ES	SES	DM
0.45	124	2	3	12	0	0	For further study		
2.0	553	7	12	55	1	1			
5.0	1382	17	29	138	2	3			

a) The bit rate translation rules of Annex D of Recommendation G.821 [1] must be applied to the measurements made at the entity rate in order to establish a comparison with the limits outlined in this table.

Note – The values in this table are for example only.

TABLE 5/M.550

Maintenance limits for 64 kbit/s digital line sections[a)]

Allocation (%)	Reference performance objective Events/24 days			Unacceptable limit Events/15 minutes			Degraded limit Events/24 hours		
	ES	SES	DM	ES	SES	DM	ES	SES	DM
0.45	31	0	1	For further study			For further study		
2.0	138	2	3						
5.0	346	4	7						

a) The bit rate translation rules of Annex D of Recommendation G.821 [1] must be applied to the measurements made at the entity rate in order to establish a comparison with the limits outlined in this table.

Note – The values in this table are for example only.

6.1 *Performance limits for digital line sections at other rates*

Performance limits for digital line sections at other rates, e.g. 1.5, 2, 6, 8, 32, 45, 97 and 140 Mbit/s are for further study.

7 Bringing-into-service and maintenance limits for digital sections

The limits are shown in Tables 6/M.550 and 7/M.550.

The duration of the test indicated in the tables is for example only and requires further study. It should be noted that some Administrations use one duration (e.g. on the order of days) for the test of the first digital section in a block and a shorter duration (e.g. on the order of hours) for the remaining sections in that block that are brought into service within a few weeks. The possibility of using shorter test durations in those cases when in-service performance monitoring will be used following the bringing-into-service test is an area for further study.

TABLE 6/M.550

Bringing-into-service limits for 64 kbit/s digital paths and sections[a)]

Allocation (%)	Reference performance objective Events/3 days			S1 limit Events/3 days			S2 limit Events/3 days		
	ES	SES	DM	ES	SES	DM	ES	SES	DM
≤ 1	207	3	4	104	1	2	For further study		
≤ 2	415	5	9	207	3	4			
≤ 3	622	8	13	311	4	6			
≤ 4	829	10	17	415	5	9			
≤ 5	1037	13	22	518	6	11			
≤ 6	1244	16	26	622	8	13			

a) The bit rate translation rules of Annex D of Recommendation G.821 [1] must be applied to the measurements made at the entity rate in order to establish a comparison with the limits outlined in this table.

Note – The values in this table are for example only.

TABLE 7/M.550

Maintenance limits for 64 kbit/s digital sections[a)]

Allocation (%)	Reference performance objective Events/24 hours			Unacceptable limit Events/15 minutes			Degraded limit Events/24 hours		
	ES	SES	DM	ES	SES	DM	ES	SES	DM
≤ 1	69	1	1	For further study			For further study		
≤ 2	138	2	3						
≤ 3	207	3	4						
≤ 4	276	4	6						
≤ 5	346	4	7						
≤ 6	415	5	8						

a) The bit rate translation rules of Annex D of Recommendation G.821 [1] must be applied to the measurements made at the entity rate in order to establish a comparison with the limits outlined in this table.

Note – The values in this table are for example only.

7.1 *Performance limits for digital sections at other rates*

Performance limits for digital sections at other rates, e.g. 1.5, 2, 6, 8, 32, 34, 45, 97 and 140 Mbit/s are for further study.

8 Bringing-into-service and maintenance limits for digital paths

Bringing-into-service limits for digital paths are the same as those for digital sections, as shown in Table 6/M.550. The maintenance limits are given in Table 8/M.550.

TABLE 8/M.550

Maintenance limits for 64 kbit/s digital paths [a)]

Allocation (%)	Reference performance objective Events/24 hours			Unacceptable limit Events/15 minutes			Degraded limit Events/24 hours		
	ES	SES	DM	ES	SES	DM	ES	SES	DM
≤ 2.5	173	2	4	For further study			For further study		
≤ 3.5	242	3	5						
≤ 4	276	4	6						
≤ 5.5	380	5	8						
≤ 6	415	5	9						

a) The bit rate translation rules of Annex D of Recommendation G.821 [1] must be applied to the measurements made at the entity rate in order to establish a comparison with the limits outlined in this table.

Note – The values in this table are for example only.

8.1 *Performance limits for digital paths at other rates*

Performance limits for digital paths at other rates, e.g. 1.5, 2, 6, 8, 32, 34, 45, 97 and 140 Mbit/s are for further study.

ANNEX A

(to Recommendation M.550)

Example performance limits

A.1 *Calculation of performance limits*

The values in the following tables are for example only.

The reference performance objectives are calculated as specified in § 5. For example, the first three numbers in Table 4/M.550 are calculated as follows:

Number of ES = 4 days × 24 × 60 × 60 × 0.0045 × 0.08 = 124

Number of SES = 4 days × 24 × 60 × 60 × 0.0045 × 0.001 = 2

Number of DM = 4 days × 24 × 60 × 0.0045 × 0.10 = 3

The value of S1 is calculated as specified in § 3.2.2. For example, the first three values in Table 4/M.550 are calculated as follows:

Number of ES = 0.1 × Reference performance objective = 12

Number of SES = 0.1 × Reference performance objective = 0.16 ≈ 0

Number of DM = 0.1 × Reference performance objective = 0.26 ≈ 0

The value of S2 is calculated from S1 by applying a statistical parameter.

The values for unacceptable and degraded performance limits are calculated from the values specified in §§ 3.2.3.1 and 3.2.3.2 and include confidence limit in addition.

It is expected that the maintenance limits will be used as thresholds for continuous in-service performance monitoring. One crossing of these thresholds (e.g. after exceeding the limits specified in Table A-2/M.550 for 24 hours) would not necessarily generate information requiring human response. Rather, as noted in the footnote to Figure 2/M.550, it would be an input to the alarm information process, which would collect inputs until a representative value has been reached (which may occur over several days) and then process such values and generate alarm information requiring human response at the apropriate time.

A.2 *Example of bringing-into-service and maintenance limits for digital line sections*

The values of Tables A-1/M.550 and A-2/M.550 are measured at the rate of the digital sections and referred to the 64 kbit/s rate using Annex D of Recommendation G.821 [1].

TABLE A-1/M.550

Example of bringing-into-service limits for 64 kbit/s digital line sections

Allocation (%)	**Reference performance objective Events/4 days**			**S1 limit Events/4 days**			**S2 limit Events/4 days**		
	ES	SES	DM	ES	SES	DM	ES	SES	DM
0.45	124	2	3	12	0	0	25	1	1
2.0	553	7	12	55	1	1	75	2	2
5.0	1382	17	29	138	2	3	175	4	6

TABLE A-2/M.550

Example of maintenance limits for 64 kbit/s digital line sections

Allocation (%)	**Reference performance objective Events/24 hours**			**Unacceptable limit Events/15 minutes**			**Degraded limit Events/24 hours**		
	ES	SES	DM	ES	SES	DM	ES	SES	DM
0.45	31	1	1	50	10	10	30	1	1
2.0	138	2	3	50	10	10	90	2	3
5.0	346	4	7	50	10	10	200	5	8

A.3 *Example of bringing-into-service and maintenance limits for digital sections*

The values of Tables A-3/M.550 and A-4/M.550 are measured at the rate of the digital sections and referred to the 64 kbit/s using Annex D of Recommendation G.821 [1].

TABLE A-3/M.550

Example of bringing-into-service limits for 64 kbit/s digital paths and sections

Allocation (%)	**Reference performance objective Events/3 days**			**S1 limit Events/3 days**			**S2 limit Events/3 days**		
	ES	SES	DM	ES	SES	DM	ES	SES	DM
≤ 1	207	3	4	104	1	2	130	2	3
≤ 2	415	5	9	207	3	4	250	4	6
≤ 3	622	8	13	311	4	6	360	6	9
≤ 4	829	10	17	415	5	9	470	7	12
≤ 5	1037	13	22	518	6	11	580	9	15
≤ 6	1244	16	26	622	8	13	690	11	18

TABLE A-4/M.550

Example of maintenance limits for 64 kbit/s digital sections

Allocation (%)	Reference performance objective Events/24 hours			Unacceptable limit Events/15 minutes			Degraded limit Events/24 hours		
	ES	SES	DM	ES	SES	DM	ES	SES	DM
≤ 1	69	1	1	100	12	12	51	2	2
≤ 2	138	2	3	100	12	12	103	3	4
≤ 3	207	3	4	100	12	12	155	4	6
≤ 4	276	4	6	100	12	12	207	5	8
≤ 5	346	4	7	100	12	12	259	6	10
≤ 6	415	5	8	100	12	12	311	7	12

A.4 *Example of bringing-into-service and maintenance limits for digital paths*

The bringing-into-service limits for digital paths are the same as those for digital sections, as shown in Table A-3/M.550.

The values of Table A-5/M.550 are usually measured at the primary rate and referred to the 64 kbit/s rate using Annex D to Recommendation G.821 [1].

TABLE A-5/M.550

Example of maintenance limits for 64 kbit/s digital paths

Allocation (%)	Reference performance objective Events/24 hours			Unacceptable limit Events/15 minutes			Degraded limit Events/24 hours		
	ES	SES	DM	ES	SES	DM	ES	SES	DM
≤ 2.5	173	2	4	120	15	15	130	2	3
≤ 3.5	242	3	5	120	15	15	181	3	4
≤ 4	276	4	6	120	15	15	207	4	5
≤ 5.5	380	5	8	120	15	15	285	5	6
≤ 6	415	5	9	120	15	15	311	6	7

References

[1] CCITT Recommendation *Error performance of an international digital connection forming part of an integrated services digital network*, Vol. III, Rec. G.821.

[2] CCITT Recommendation *Controlled slip rate objectives on an international digital connection*, Vol. III, Rec. G.822.

[3] CCITT Recommendation *The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy* Vol. III, Rec. G.823.

[4] CCITT Recommendation *The control of jitter and wander within digital networks which are based on the 1544 kbit/s hierarchy*, Vol. III, Rec. G.824.

[5] CCITT Recommendation *ISDN user-network interfaces - Interface structures and access capabilities*, Vol. III, Rec. I.412.

[6] CCITT Recommendation *Digital hierarchy bit rates*, Vol. III, Rec. G.702.

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[9] CCITT Recommendation *Digital line sections at 1544 kbit/s, Red Book*, Vol. III, Rec. G.911, ITU, Geneva, 1984.

[10] CCITT Recommendation *Functional characteristics of interfaces associated with network nodes*, Vol. III, Rec. G.704.

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