RECOMMENDATION ITU-R F.1492*

AVAILABILITY OBJECTIVES FOR REAL DIGITAL RADIO-RELAY LINKS FORMING PART OF INTERNATIONAL PORTION CONSTANT BIT RATE DIGITAL PATH AT OR ABOVE THE PRIMARY RATE

(Question ITU-R 102/9)

(2000)

The ITU Radiocommunication Assembly,

considering

a) that ITU-T has specified the availability parameters and objectives for path element of international constant bit rate digital paths at or above the primary rate (see ITU-T Recommendation G.827);

b) that digital radio-relay systems play an important role in international path;

c) that it is necessary for the availability of radio-relay systems to be compliant with the path element availability objectives specified in ITU-T Recommendation G.827;

d) that digital radio-relay systems may be used in intermediate and terminating countries of an international path;

e) that for the international path element of a constant bit rate digital path at or above the primary rate ITU-T Recommendation G.827 specifies fixed-block allocation plus distance-based allocations for the availability objectives;

f) that unavailability of radio-relay systems may be due to propagation effects, equipment failures, human interventions, interference or other causes;

g) that the availability objectives, availability ratio (AR) and mean time between outage (Mo) or its reciprocal, outage intensity (OI), are needed for design purposes,

recommends

1 that availability objectives applicable to any real digital radio-relay link forming part of the international portion of a constant bit rate digital path at or above the primary rate should be fixed-block plus distance-base allocated;

2 that the availability objectives applicable to each direction of a radio-relay link of length L_{link} at or above the primary rate can be derived from values given in Tables 1 and 2 by using equations (1) and (2) for AR and Mo or, the reciprocal of Mo defined as OI objectives, respectively.

$$AR = 1 - \left(B_j \frac{L_{link}}{L_R} + C_j \right) \tag{1}$$

$$Mo = \frac{1}{D_j \frac{L_{link}}{L_R} + E_j} \tag{2}$$

where:

the value of j is:	1	for	L_{min}	$< L_{link}$	$\leq$	250 km
	2	for	250 km	$< L_{link}$	$\leq$	2 500 km
	3	for	2 500 km	$< L_{link}$	$\leq$	7 500 km
	4	for		L_{link}	$>$	7 500 km

L_R is the reference length L_R = 2 500 km.

The lower limit of L_{link} used to scale the objectives is L_{min} equal to 50 km.

The values of B_j, C_j, D_j and E_j are given in Tables 1 and 2.

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* This Recommendation should be brought to the attention of Telecommunication Standardization Study Group 13.

The parameter OI refers to the number of unavailability events per year, so its reciprocal Mo has to be multiplied by the number of seconds in a year to represent the effective mean time between the unavailability events that have occurred in a year expressed in seconds;

3 that availability objectives should be partitioned in order to take into account unavailability events due to propagation, equipment failures, human interventions and other causes. The partitioning of objectives for the different unavailability causes is outside the scope of this Recommendation;

4 that for the case when the link is composed of more than 1 hop, the objectives are applicable for whole link. The scaling of the objectives for each individual hop is under the network operator responsibility (see Annex 1 for more information);

5 that the objectives for radio link forming part of any path element composing the international portion (i.e. inter-country path core element (ICPCE) and international path core element (IPCE)) should in any case not exceed the objectives defined in ITU-T Recommendation G.827 (see Annex 1 for more information).

NOTE 1 – The international portion of a constant bit rate digital path at or above the primary rate is composed of at least one ICPCE and/or one IPCE.

NOTE 2 – ICPCE is the path element (PE) carried on the highest order digital path across the border between two countries. The ICPCE is the link between networks in different countries, considered as subnetworks. This PE is limited by the frontier stations (FSs) where the highest order inter-country path may be terminated. When the highest order inter-country path is not terminated in the FS, the ICPCE is limited by the supporting inter-country section access point.

NOTE 3 – IPCE is the PE used in a core network. The boundary of this PE depends on its application; for a transit country this PE is limited by the two FSs. For a terminating country, this element is limited by the international gateway (IG) and the FS. In particular this element should be delimited by the international switching centre (ISC) and the FS or by the terminal international centre (TIC), which corresponds to the end of the international portion, and the FS. The TIC is defined in ITU-T Recommendation M.1010. (Note that the ISC and TIC may be in the same location.)

NOTE 4 – The international portion of a path is composed by the ICPE and ICPCE, so the boundary of this element corresponds to the IPCE (i.e. FS or TIC or ISC) and by the portion of ICPCE that crosses the border between two countries.

NOTE 5 – The criteria defining the entry to and exit from the unavailable state is defined in § A.1 of Annex A of ITU-T Recommendation G.826.

NOTE 6 – Further studies are invited to establish whether and to what extent the AR and the OI objectives can be improved.

TABLE 1

Parameters for AR objectives for links forming part of an international portion of constant bit rate digital path at or above the primary rate

Length (km)	$L_{min} \le L_{link} \le 250$		$250 < L_{link} \le 2\,500$		$2\,500 < L_{link} \le 7\,500$		$L_{link} > 7\,500$	
	B_1	C_1	B_2	C_2	B_3	C_3	B_4	C_4
International portion	1.9×10^{-3}	1.1×10^{-4}	3×10^{-3}	0	3×10^{-3}	0	For further study	For further study

TABLE 2

Parameters for OI objectives for links forming part of an international portion of constant bit rate digital path at or above the primary rate

Length (km)	$L_{min} \le L_{link} \le 250$		$250 < L_{link} \le 2\,500$		$2\,500 < L_{link} \le 7\,500$		$L_{link} \ge 7\,500$	
	D_1	E_1	D_2	E_2	D_3	E_3	D_4	E_4
International portion	150	50	100	55	For further study	For further study	For further study	For further study

ANNEX 1

Terminology and examples of evaluation for real link

1 Introduction

This Annex gives further information on the meaning of terms related to the connection, on the relationship between the objectives given by ITU-T Recommendation G.827 and the objectives defined in this Recommendation and some examples of the evaluation of the objectives for a real radio link.

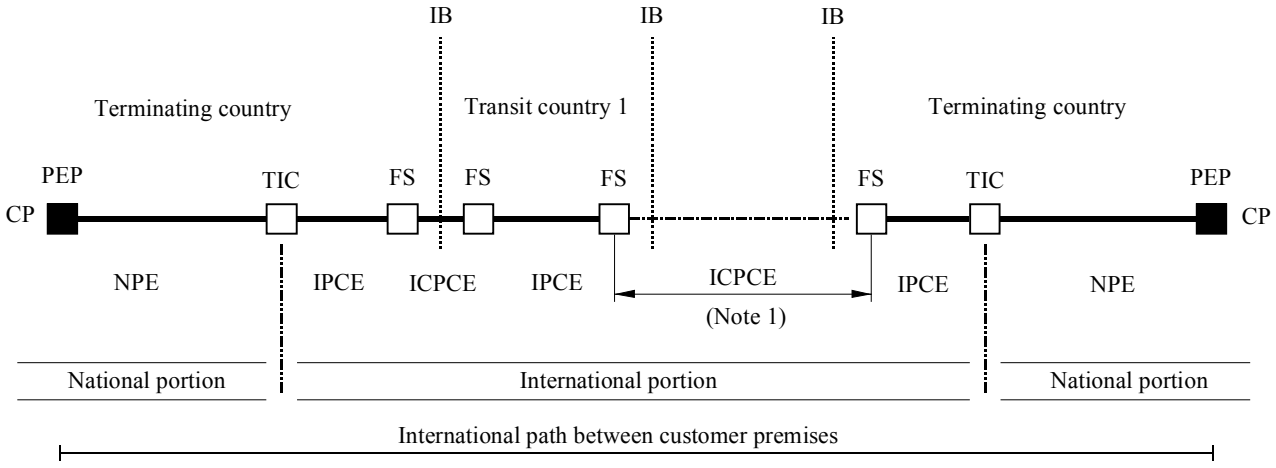
2 Definition and terminology

The scope of this Recommendation is to define the availability objectives for a real radio link, but since in a telecommunication network the term link is quite general the clarification of the meaning of this term within the context of the current Recommendation is given below.

The definition of PE is given in ITU-T Recommendation G.827. An example of path composed by several PEs is shown in Fig. 1. A radio link can be identified with a portion of the path and it can implement an IPCE (or a portion of it) and/or an ICPCE, as shown in Fig. 2. Moreover a link can be formed by several hops.

FIGURE 1

Conceptual location of the elements of an international path between customer premises



PEP: Path end point
IB: International border
NPE: National path element
CP: Customer premises

Note 1 – This ICPCE crosses two international borders and is typically supported by a satellite or undersea transmission system.

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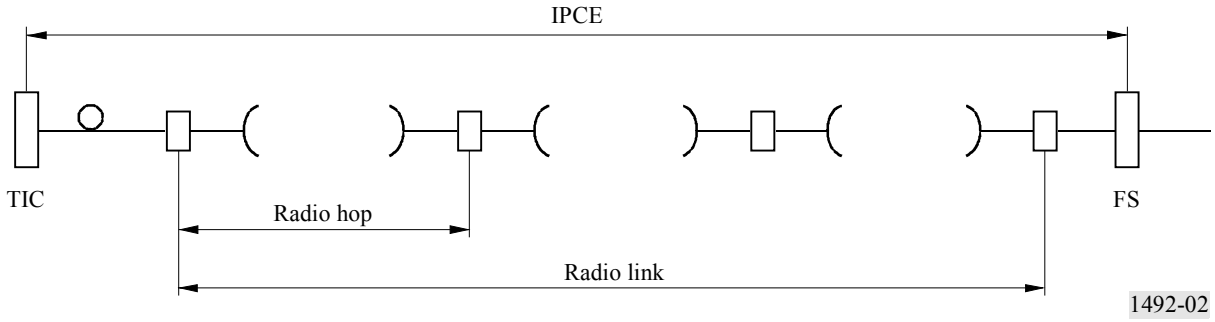
Historically the terminology used in ITU-T Recommendation G.827 is derived from maintenance requirements for international paths, since availability is one of the main factors influencing the behaviour of radio path. In fact, in the past, error performance requirements were a negligible factor, so they were not considered. Nowadays, from the point of view of maintenance, error performance has the same importance as availability. Furthermore performance and availability requirements are the fundamental requisites for the design of links.

FIGURE 2

Example of a radio link implementing a portion of IPCE

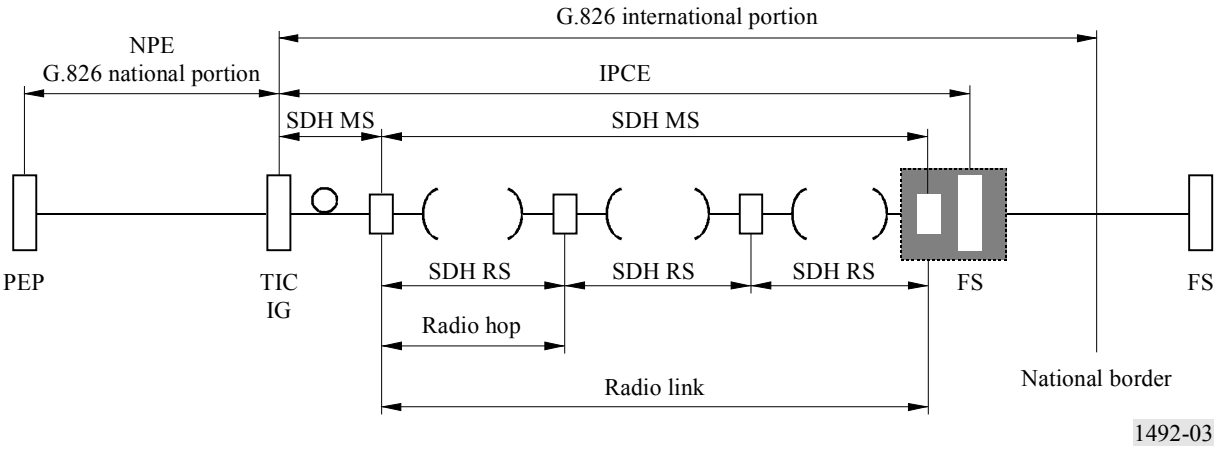


Moreover, the performance objectives, defined in Recommendations ITU-R F.1092, ITU-R F.1189, ITU-R F.1397 and in ITU-T Recommendations G.826, G.828 and G.829 for plesiochronous digital hierarchy (PDH), synchronous digital hierarchy (SDH) and cell-based paths, are based on different elements of a path. In particular the elements composing an SDH are the multiplex section (MS) and the regenerators section (RS), which are the basis for performance definitions. In order to clarify the relationship between performance and availability objectives, the relationship between the SDH sections and PEs should be explained.

Figure 3 shows an example of a radio link implementing a portion of an IPCE PE and composed of SDH MS and RS. The objectives of this Recommendation are applicable to the radio link, while the objectives of Recommendation ITU-R F.1397 are applicable to the single SDH MS and RS implemented by radio. The subdivision of availability and performance objectives to each hop is outside the scope of this Recommendation and of Recommendation ITU-R F.1397.

FIGURE 3

Example of a radio link implementing a portion of the IPCE



For the design of a radio link, besides the objectives, propagation effects should be considered carefully, since the relation between availability and performance is defined by propagation phenomena. In fact generally speaking a propagation phenomena may have a greater influence on performance, but lesser on availability, or vice versa.

The availability objective of a radio link as defined in this Recommendation should be compliant with the IPCE objectives defined by ITU-T Recommendation G.827.

3 Relationship between objectives given in ITU-T Recommendation G.827 and in this Recommendation

In this section the relationship between the objectives of ITU-T Recommendation G.827 and of this Recommendation are compared and shown in Figs. 4 and 5.

ITU-T Recommendation G.827 defines two kinds of objectives called "mean value" and "worst-case value". The mean value objectives for PE are defined for network design purposes, in fact the value should be evaluated by means of mathematical average on PE of the same categories considering transmission system in a media independent environment.

In Fig. 4 the AR objectives are compared. The choice to align the objectives of this Recommendation to those of ITU-T Recommendation G.827 would result in a less stringent figure with respect to those that have been used up to now for radio applications (defined in Recommendations ITU-R F.557 and ITU-R F.696). Therefore, it has been decided to align the objectives given in this Recommendation to the existing figures. As it can be seen, the resulting objectives are more stringent than ITU-T Recommendation G.827 for any length. The numerical values for some link length is reported in Table 3.

FIGURE 4

Relationship between AR objectives defined in ITU-T Recommendation G.827 and in this Recommendation

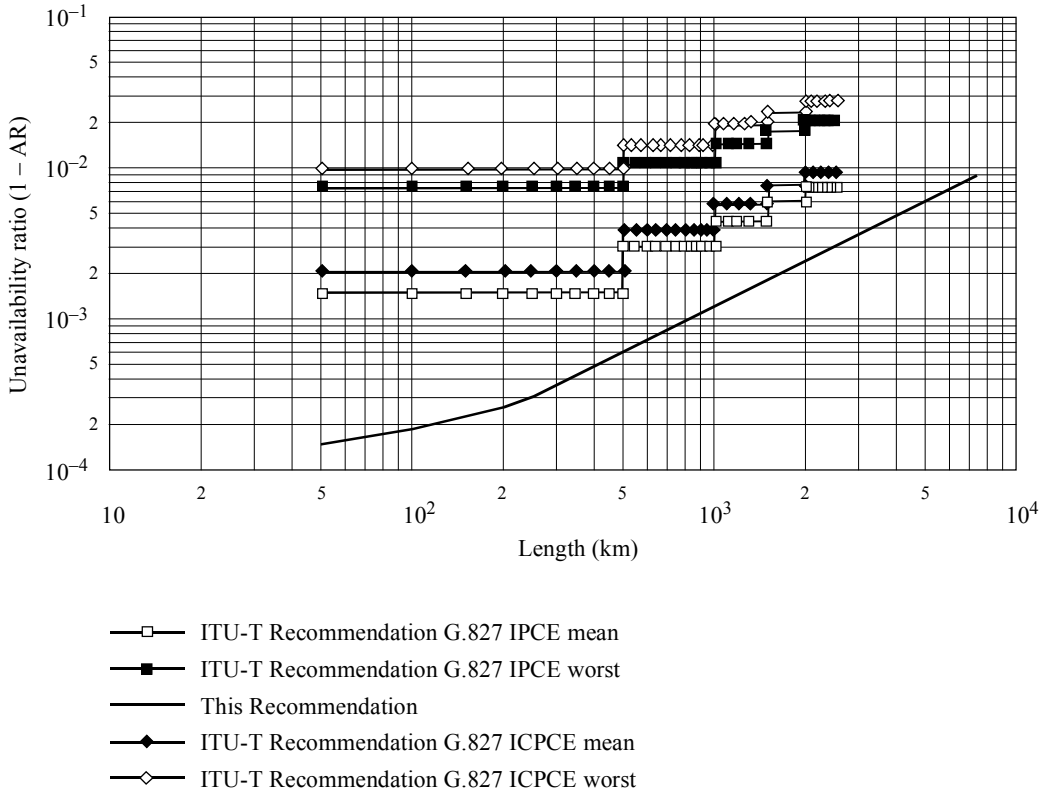


FIGURE 5

Relationship between OI objectives defined in ITU-T Recommendation G.827 and in this Recommendation

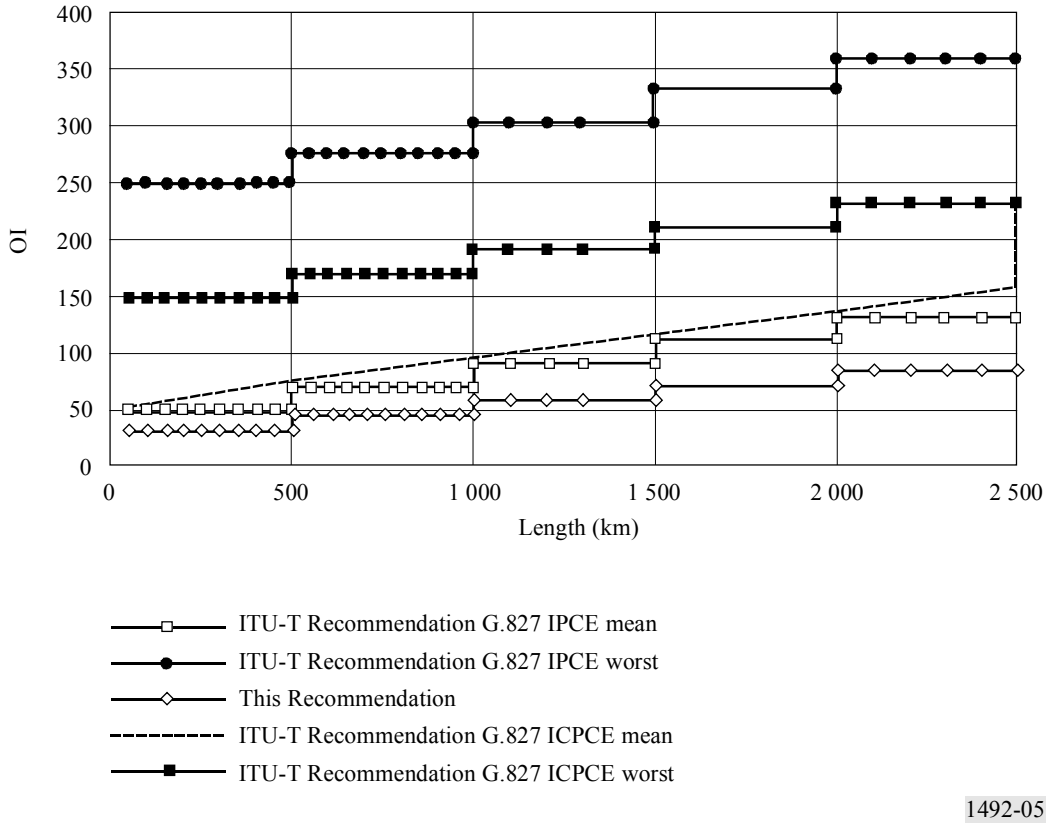


TABLE 3

Example of objectives for links forming part of an international portion of constant bit rate digital path at or above the primary rate

Link length (km)	50	100	200	250	500	750	1 000	1 500	2 000	2 500
AR (%)	99.985	99.9813	99.9738	99.97	99.94	99.91	99.88	99.82	99.76	99.7
Unavailability ratio (1 – AR)	1.5×10^{-4}	1.875×10^{-4}	2.625×10^{-4}	3×10^{-4}	6×10^{-4}	9×10^{-4}	1.2×10^{-3}	1.8×10^{-3}	2.4×10^{-3}	3×10^{-3}
OI	53	56	62	65	75	85	95	115	135	155

4 Calculation of availability objectives

This section shows some examples of the application of this Recommendation to real links, in order to derive the objectives.

4.1 Case 1: length 30 km

The length is shorter than L_{min} = 50 km, so the value of L_{link} = 50 has been used.

$$AR = 1 - \left(B_1 \frac{L_{link}}{L_R} + C_1 \right) = 1 - \left(1.9 \times 10^{-3} \frac{50}{2\ 500} + 1.1 \times 10^{-4} \right) = 0.99985$$

$$Mo = \frac{1}{D_1 \frac{L_{link}}{L_R} + E_1} = \frac{1}{130 \frac{50}{2\ 500} + 100} = \frac{1}{102.6} = 9.74 \times 10^{-3}$$

These values correspond to an AR of 99.985% (unavailability of 79 min/year), number of events per year of OI = 103 and the mean time between unavailability events Mo = 5 119 min.

4.2 Case 2: length 80 km

The length is in the range 50 km-250 km, so:

$$AR = 1 - \left(B_1 \frac{L_{link}}{L_R} + C_1 \right) = 1 - \left(1.9 \times 10^{-3} \frac{80}{2\ 500} + 1.1 \times 10^{-4} \right) = 0.99983$$

$$Mo = \frac{1}{D_1 \frac{L_{link}}{L_R} + E_1} = \frac{1}{130 \frac{80}{2\ 500} + 100} = \frac{1}{104.16} = 9.60 \times 10^{-3}$$

These values correspond to an AR of 99.983% (unavailability of 91 min/year), number of events per year of OI = 104 and the mean time between unavailability events Mo = 5 046 min.

4.3 Case 3: length 1 056 km

The length is in the range 250 km-2 500 km, so:

$$AR = 1 - \left(B_1 \frac{L_{link}}{L_R} + C_1 \right) = 1 - \left(3 \times 10^{-3} \frac{1\ 056}{2\ 500} + 0 \right) = 1 - 1.27 \times 10^{-3} = 0.998732$$

$$Mo = \frac{1}{D_1 \frac{L_{link}}{L_R} + E_1} = \frac{1}{130 \frac{1\ 056}{2\ 500} + 100} = \frac{1}{154.92} = 6.45 \times 10^{-3}$$

The previous values correspond to an AR of 99.873% (unavailability of 667 min/year), number of events per year of OI = 155 and the mean time between unavailability events Mo = 3 390 min.