

RECOMMENDATION ITU-R F.1493\*

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

(Question ITU-R 102/9)

(2000)

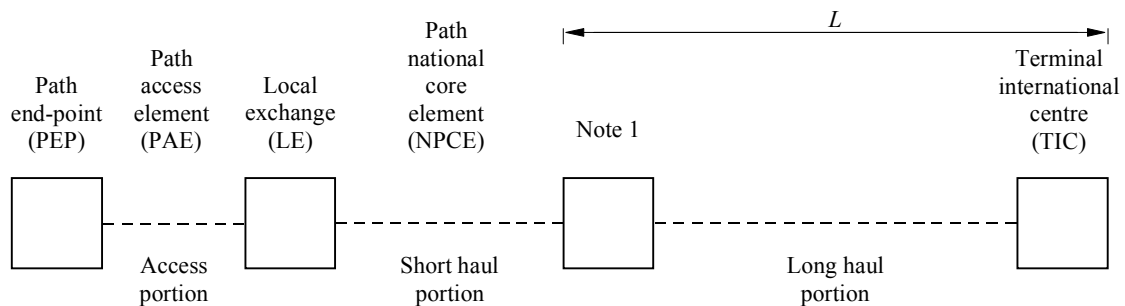
The ITU Radiocommunication Assembly,

*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 the national portion of an international path;
- e) that for the purpose of this Recommendation, the national portion of an international path can be identified with the national path element (NPE) defined by ITU-T Recommendation G.827;
- f) that for the purposes of this Recommendation the national portion can be subdivided in three basic sections (see Fig. 1);

FIGURE 1

**Basic sections of the national portion of the hypothetical reference path**



*Note 1* – Depending on the country network architecture, this centre may coincide with a primary centre (PC), secondary centre (SC) or tertiary centre (TC) (see ITU-T Recommendation G.801).

*Access*: Access network section, including the connections between PEP and the corresponding local access switching centre/cross connector LE. It corresponds to the PAE.

*Short haul*: Short haul network portion, including the connections between a local access switching centre/cross connector, LE, and a PC, SC or TC (depending on the network architecture).

*Long haul*: Long haul network portion, including the connections between a PC, SC or TIC (depending on the network architecture) and the corresponding international gateway (IG).

*Note 2* – TIC, PAE and NPCE are defined in ITU-T Recommendation M.1010.

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

- g) that for the NPE 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;
- h) that unavailability of radio-relay systems may be due to propagation effects, equipment failures, human interventions, interference or other causes;
- j) that the unavailability parameters, 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 link belonging to the long haul network portion of the national portion of an international constant bit rate digital path at or above the primary rate should be fixed block plus distance-base allocated;
- 2 that availability objectives applicable to any real digital radio link belonging to the access and short haul network portions of the national portion of an international constant bit rate digital path at or above the primary rate should be fixed block-based (i.e. length independent);
- 3 that the availability objectives applicable to each direction of a radio-relay link of length,  $L_{link}$ , in the national portion at or above the primary rate can be derived from the values in Tables 1 and 2 by means of equations (1) and (2) for the AR and Mo, or the reciprocal of Mo defined as OI objectives, respectively;

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

$$Mo = 1/OI = \frac{1}{D_j \frac{L_{link}}{L_R} + E_j} \quad (2)$$

where:

$j$ : section of national portion,  $j = \{1 = \text{access network}, 2 = \text{short haul}, 3 = \text{long haul}\}$

the values of  $B_j$ ,  $C_j$ ,  $D_j$  and  $E_j$  are given in Tables 1 and 2

$L_R$ : reference length  $L_R = 2\,500$  km.

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

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;

- 4 that availability objectives should be partitioned in order to take into account unavailability events due to propagation events, equipment failures, human intervention and other causes. The partitioning of objectives for the different unavailability causes is outside the scope of this Recommendation and is under the responsibility of administrations and/or network operators;
- 5 that for the case when the link is composed of more than 1 hop, the objectives are applicable for the whole link. The scaling of the objectives for each individual hop is under the responsibility of administrations and/or network operators (see Annex 1 for more information);
- 6 that the overall objectives for the national portion (i.e. obtained by adding the objectives of access network, short haul and long haul) implemented by radio-relay systems should not exceed in any case the objectives defined in ITU-T Recommendation G.827 for the National Portion Element (see Note 1).

NOTE 1 – The NPE is a path element (PE) used in a terminating country to connect the international portion and the PEP. The NPE includes both the PAE and the NPCE.

NOTE 2 – For the scope of this Recommendation the national portion corresponds to the NPE.

NOTE 3 – The TIC, the PAE and NPCE are defined in ITU-T Recommendation M.1010. (Note that the international switching centre (ISC) and TIC may be in the same location.)

NOTE 4 – The criteria for entry to and exit from the unavailable state is defined in Annex 1 of ITU-T Recommendation G.826.

NOTE 5 – The objectives for access portion of the network are assumed length independent, since typically these links are shorter than 50 km.

NOTE 6 – The objectives for access portion and short haul portion are defined for a maximum length  $L_{max} = 250$  km.

NOTE 7 – The short haul objectives for length greater than 2 500 km are not applicable.

NOTE 8 – The mean value objectives for PE are not considered, since they are obtained by means of mathematical average on PE of the same categories considering transmission system either in cable or in radio. So for design purposes of radio links only worst-case value objectives should be considered.

NOTE 9 – The overall objectives of a radio link should not exceed the worst-case objectives defined by ITU-T Recommendation G.827 for NPE for the corresponding length categories.

NOTE 10 – Depending on national network configurations administrations and/or network operators may reallocate the objectives allowances among the elements of the national portion of a radio path.

NOTE 11 – There is a great variety in the architecture of access networks in different countries. If the radio path consists of more than one hop and/or forms only part of the access network portion, it is at the prerogative of administrations and/or network operators to make an appropriate apportionment of the objectives given in Tables 1 and 2.

NOTE 12 – 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 a national portion of constant bit rate digital path element at or above the primary rate**

Access portion		Short haul portion		Long haul portion	
$B_1$	$C_1$	$B_2$	$C_2$	$B_3$	$C_3$
0	$5 \times 10^{-4}$	0	$4 \times 10^{-4}$	$3 \times 10^{-3}$ for $250 \text{ km} \leq L_{link} < 2\,500 \text{ km}$ $1,9 \times 10^{-3}$ for $L_{min} \leq L_{link} < 250 \text{ km}$	0 for $250 \text{ km} \leq L_{link} < 2\,500 \text{ km}$ $1,1 \times 10^{-4}$ for $L_{min} \leq L_{link} < 250 \text{ km}$

TABLE 2

**Parameters for OI objectives for links forming part of a national portion of constant bit rate digital path element at or above the primary rate**

Access portion		Short haul portion		Long haul portion	
$D_1$	$E_1$	$D_2$	$E_2$	$D_3$	$E_3$
0	100	0	120	100 for $250 \text{ km} \leq L_{link} < 2\,500 \text{ km}$ 150 for $L_{min} \leq L_{link} < 250 \text{ km}$	55 for $250 \text{ km} \leq L_{link} < 2\,500 \text{ km}$ 50 for $L_{min} \leq L_{link} < 250 \text{ km}$

## Terminology and examples of evaluation for real links

### 1 Introduction

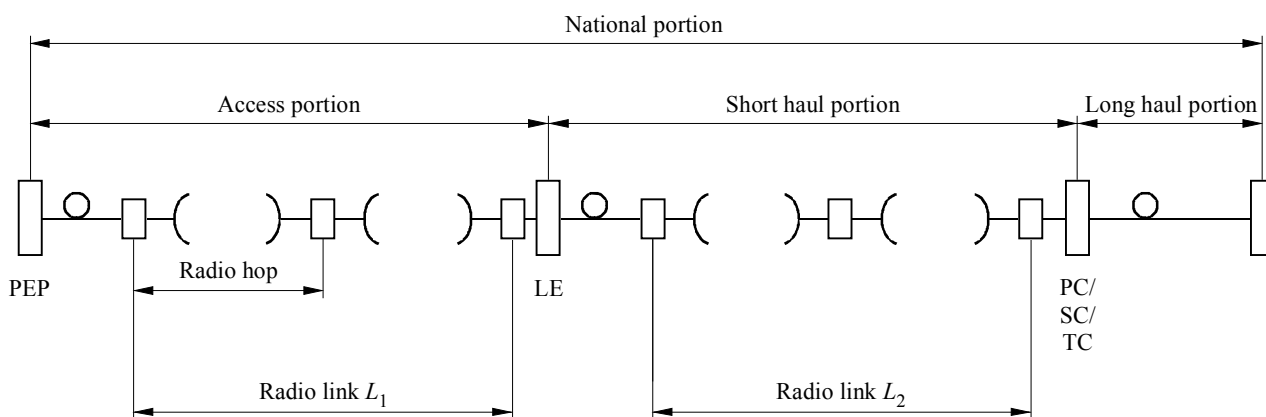
This Annex gives further information on the meaning of terms related to the connection, on the relationship between the objectives given by ITU-T Recommendation G.827 and the objectives defined in this Recommendation and some examples of evaluation of the objectives for real radio links.

### 2 Definition and terminology

The scope of this Recommendation is to define the availability objectives for real radio links belonging to the NPE, defined in ITU-T Recommendation G.827. A radio link can be identified with a portion of the path and it can belong to any portion of the network, as shown in Fig. 2.

FIGURE 2

Example of radio links used in access portion and short haul portion of NPE



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.

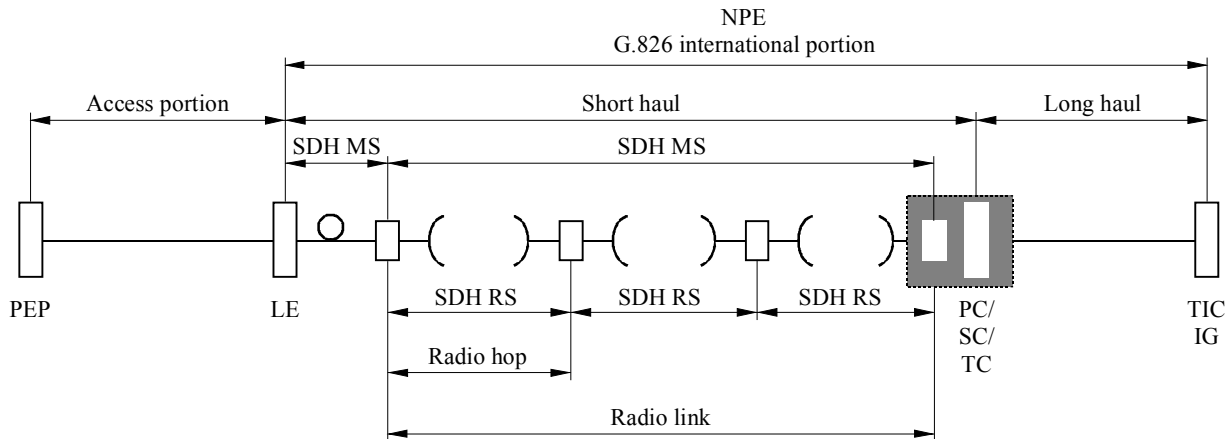
Moreover, the error performance objectives, defined in Recommendations ITU-R F.1092, ITU-R F.1189, ITU-R F.1397 and in ITU-T Recommendations G.826, G.828 and G.829 for plesiochronous digital hierarchy (PDH), synchronous digital hierarchy (SDH) and cell-based paths, are based on different elements of a path. In particular the elements composing an SDH are the multiplex section (MS) and the regenerator section (RS), which are the basis for performance definitions. In order to clarify the relationship between error 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 part of a short haul portion and composed of SDH MS and RS. The objectives of this Recommendation are applicable to the radio link, while the error performance objectives of Recommendation ITU-R F.1491 are applicable to the single SDH MS and RS implemented by radio. The apportionment of availability and error performance objectives to each hop is outside the scope of this Recommendation and of Recommendation ITU-R F.1491.

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 shall be compliant with the NPE objectives defined by ITU-T Recommendation G.827.

FIGURE 3  
Example of a radio link implementing a portion of the NPE



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

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

ITU-T Recommendation G.827 defines two kind 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. Since the scope of this Recommendation is to define the objectives for design purposes, only the worst-case values have been referred to.

In Fig. 4 the unavailability ratio (UR) ( $UR = 1 - AR$ ) objectives are compared. The objectives given in this Recommendation are aligned with the existing figures defined in Recommendations ITU-R F.696 and ITU-R F.697.

### 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 in access portion

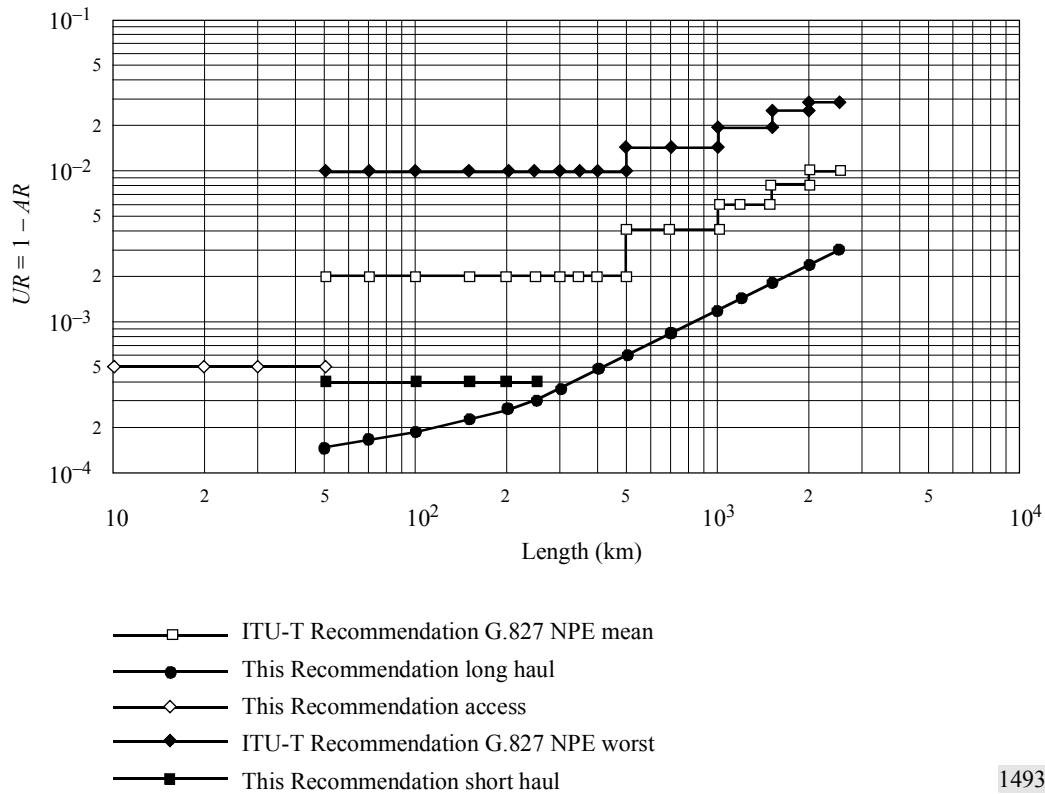
The length is shorter than  $L_{min} = 50$  km, so the value of  $L_{link} = 50$  km has been used.

$$AR = 1 - \left( B_1 \frac{L_{link}}{L_R} + C_1 \right) = 1 - \left( 0 \frac{50}{2500} + 5 \times 10^{-4} \right) = 0.9995$$

$$Mo = \frac{1}{D_1 \frac{L_{link}}{L_R} + E_1} = \frac{1}{0 \frac{50}{2500} + 100} = 1 \times 10^{-2}$$

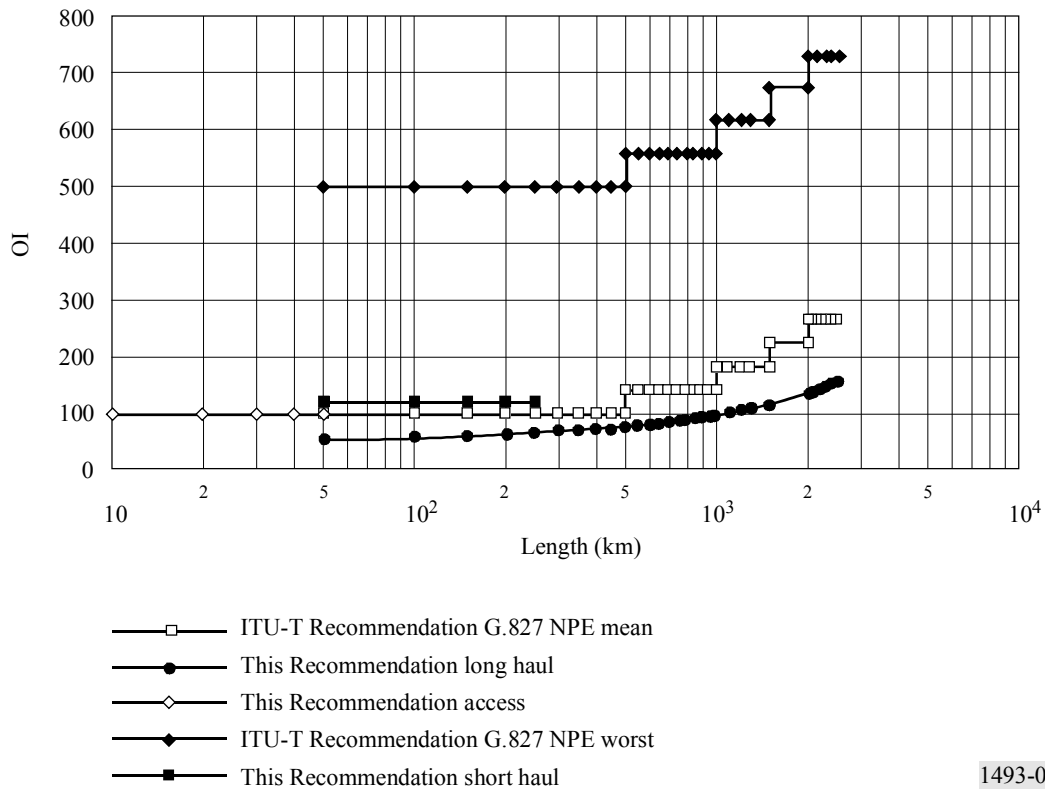
These values correspond to an AR of 99.95% (unavailability of 263 min/year), number of events per year of OI = 100 and the mean time between unavailability events  $Mo = 5\,256$  min.

FIGURE 4  
 Relationship between AR objectives defined in ITU-T Recommendation G.827  
 and in this Recommendation



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FIGURE 5  
 Relationship between OI objectives defined in ITU-T Recommendation G.827  
 and in this Recommendation



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#### 4.2 Case 2: length 105 km in short haul portion

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

$$AR = 1 - \left( B_1 \frac{L_{link}}{L_R} + C_1 \right) = 1 - \left( 0 \frac{105}{2500} + 4 \times 10^{-4} \right) = 0.9996$$

$$Mo = \frac{1}{D_1 \frac{L_{link}}{L_R} + E_1} = \frac{1}{0 \frac{105}{2500} + 120} = 8.34 \times 10^{-3}$$

These values correspond to an AR of 99.96% (unavailability of 210 min/year), number of events per year of OI = 120 and the mean time between unavailability events  $Mo = 4\,380$  min.

#### 4.3 Case 3: length 960 km in long haul portion

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

$$AR = 1 - \left( B_1 \frac{L_{link}}{L_R} + C_1 \right) = 1 - \left( 3 \times 10^{-3} \times \frac{960}{2500} + 0 \right) = 0.9988$$

$$Mo = \frac{1}{D_1 \frac{L_{link}}{L_R} + E_1} = \frac{1}{100 \frac{960}{2500} + 55} = 1.071 \times 10^{-2}$$

These values correspond to an AR of 99.88% (unavailability of 606 min/year), number of events per year of OI = 93 and the mean time between unavailability events  $Mo = 5\,627$  min.

#### 4.4 Case 4: overall objectives for a link of 1 095 km length composed by 30 km in access portion, 105 km in short haul portion and 960 km in long haul portion

The AR objectives of this link are given by the sum of the unavailability objectives referred to the portion of the link belonging to each network portion:

$$AR = 1 - UR = 1 - (UR_{AN} + UR_{SH} + UR_{LH}) = 1 - (5 \times 10^{-4} + 4 \times 10^{-4} + 1.15 \times 10^{-3}) = 0.9979$$

where:

$UR$ : total unavailability ratio

$UR_{AN}$ : unavailability ratio objective of the access portion

$UR_{SH}$ : unavailability ratio objective for short haul portion

$UR_{LH}$ : unavailability ratio objective for long haul portion (see above reported examples).

The  $Mo$  objective is given by the reciprocal of the sum of OI objectives referred to the part of link belonging to each network portion:

$$Mo = \frac{1}{OI_{AN} + OI_{SH} + OI_{LH}} = \frac{1}{100 + 120 + 93} = 3.19 \times 10^{-3}$$

where:

$Mo$ : total mean time between outage

$OI_{AN}$ : outage intensity objective of the access portion

$OI_{SH}$ : outage intensity objective for short haul portion

$OI_{LH}$ : outage intensity objective for long haul portion (see above reported examples).

These values correspond to an AR of 99.795% (unavailability of 1 077 min/year), number of events per year OI = 313 and the mean time between unavailability events  $M_o = 1\,674$  min.

According to ITU-T Recommendation G.827 the objectives for a 1 095 km NPE are:

- AR mean value = 0.994
- AR worst-case value = 0.98083
- OI mean = 183
- OI worst case = 614.

In this example the overall objectives are compliant with ITU-T Recommendation G.827.

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