INTERNATIONAL TELECOMMUNICATION UNION

ITU-T G.801

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

DIGITAL NETWORKS

DIGITAL TRANSMISSION MODELS

ITU-T Recommendation G.801

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation G.801 was published in Fascicle III.5 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 G.801

DIGITAL TRANSMISSION MODELS

(Malaga-Torremolinos, 1984)

The CCITT

considering

(a) that digital networks support a wide variety of connections for which digital transmission impairments and other performance parameters need to be controlled;

(b) that, if proper control is not exercised, then under certain circumstances, digital transmission impairments cause unacceptable service degradations;

(c) that various network performance objectives need to be allocated to the elements of a digital network;

(d) that equipment design objectives need to be formulated for individual digital elements;

(e) that networks need to be configured to a level of transmission quality consistent with the needs of different services (voice and non-voice) and in particular of services in the ISDN;

(f) that Administrations need to examine the effect on transmission quality of possible changes of impairment allocation in national networks;

(g) that there is a need to test national rules for prima facie compliance with any impairment criteria which may be recommended by the CCITT for national and international systems,

(h) that guidelines need to be formulated governing the use of certain digital elements (e.g. satellite links, transcoders, digital pads, circuit multiplication devices, etc.),

recommends

that in the study of digital transmission impairments and other performance parameters, the following network models and associated guidelines should be applied.

1 Introduction

Digital transmission network models are hypothetical entities of a defined length and composition for use in the study of digital transmission impairments (e.g. bit errors, jitter and wander, transmission delay, availability, slip, etc.). The diversity of possible network situations requires that individual models can only represent a small portion of typical real entities. However, a limited number of such models (e.g. 2 or 3) together may be sufficiently representative to provide a useful tool upon which studies may be based.

The network models, where applicable, take account of the following features:

a) physically reflect the length of the overall connection with some indication of frequency of occurrence,

b) identify boundaries between switching and transmission elements,

c) give no indication of the means of implementing transmission between switching elements (e.g. metallic, optical, radio media, satellite etc.),

d) describe in detail the user/network access arrangement in the local portion (i.e. customer to local exchange),

e) take account of all possible usages or be independent of them,

f) reflect the use of additional digital processing elements required in particular network configurations (e.g. A-μ converters, digital pads, transcoders, etc.).

This Recommendation makes no statement in respect of the electrical and physical environment in which the network models operate. These aspects are currently the subject of study. In the application of these network models to the study of specific digital impairment (e.g. errors) arbitrary judgements may need to be made concerning the significance, in particular, of the electrical environment.

2 Hypothetical reference connection (HRX)

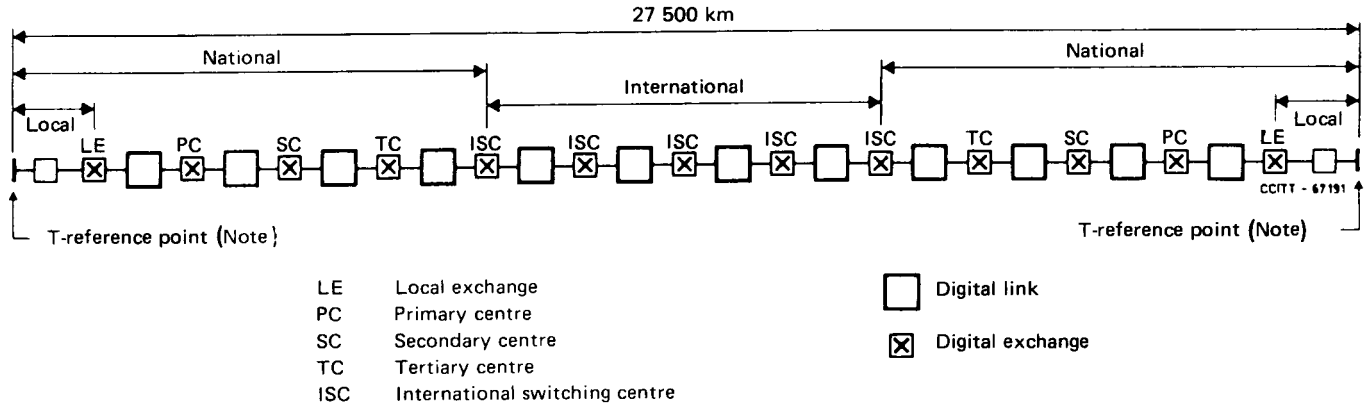
A digital HRX is a model in which studies relating to overall performance may be conducted, thereby facilitating the formulation of standards and objectives. In order to initiate studies directed at the performance of an ISDN, an all digital 64 kbit/s connection is considered. Since the overall network performance objectives for any performance parameter need to be consistent with user requirements, such objectives, in the main, should relate to a network model which is representative of the very long connection. The HRX shown in Figure 1/G.801 serves this purpose. It does not represent the rare worst case connection; although it does aim to encompass the vast majority of connections for each relation. Moreover, the difficulty of identifying every conceivable practical implementation of a connection and the undesirability of producing too many options naturally requires that this "standard HRX" may need to be appropriately modified in composition to suit the particular task in hand. A situation can be envisaged where many similar HRXs exist to serve specific functions, but in all cases they are derivatives of the "standard HRX". The potential proliferation of HRXs prevent their inclusion in this Recommendation. Any departure from the "standard HRX" may need to be shown in the Recommendation appropriate to that impairment or performance parameter. For example, see Recommendation G.821. They are not intended to be used for the design of transmission systems.

The diversity in composition is particularly apparent when a distinction is made between average size and large countries and, therefore no one HRX can possibly accommodate such variations. In the process of apportionment the demarcation between national and international portions is unimportant as in most instances the intrinsic quality of circuit comprising both portions is the same. In contrast, however, the overall length is regarded as being critical and its choice is "country size" independent. Accordingly, the level of impairment actually experienced over a real connection is considered satisfactory if compatible with that stipulated for the longest HRX, taking due account of differences between the construction of the hypothetical and real connections. For a large proportion of real connections configured using equipment designs recommended by CCITT, the actual performance is likely to be significantly better. Those CCITT compliant connections which exceed the longest HRX in either length or complexity may not have controlled levels of performance; however, their impairment levels are unlikely to exceed those of the longest HRX by more than a factor of 2 and the design margins provided with individual items of equipment may well bring the impairment to within CCITT end-to-end performance specifications.

In formulating the above HRX no account was taken of the following aspects:

- maritime applications,
- semi-automatic connections (i.e. auto-manual),
- standby routing in case of failure.

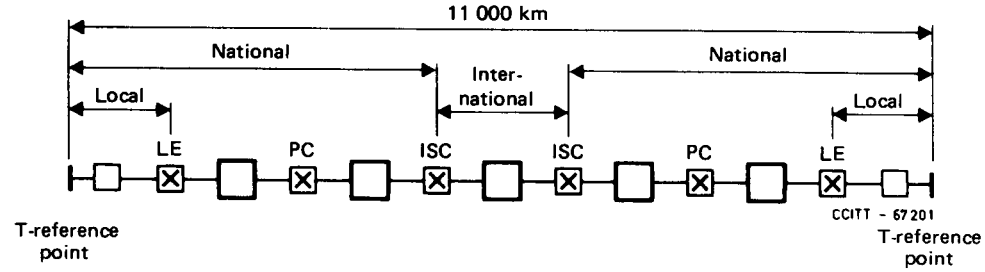
Two other HRXs have been included to facilitate studies over shorter connections with a view to establishing the typical performance levels likely to be achieved over frequently realized international circuits. These are given in Figures 2/G.801 and 3/G.801.



Note – Recommendation I.411 (applicable to ISDN only).

FIGURE 1/G.801

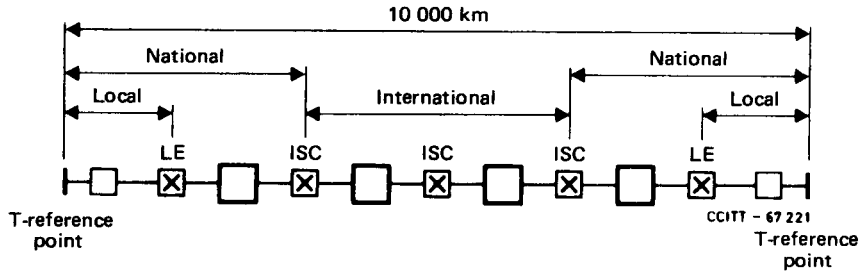
Standard digital hypothetical reference connection (longest length)



Note – See Figure 1/G.801 for legend.

FIGURE 2/G.801

Standard digital hypothetical reference connection (moderate length)



Note – See Figure 1/G.801 for legend.

FIGURE 3/G.801

Standard digital hypothetical reference connection (moderate length with subscriber situated near the International Switching Centre (ISC))

3 Hypothetical reference digital link (HRDL)

To facilitate the study of digital transmission impairments (e.g. bit errors, jitter and wander, slip, transmission delay) it is necessary to define network models comprising a combination of different types of transmission elements (e.g. transmission systems, multiplexers, demultiplexers, digital pads, transcoders). Such a model is defined as a Hypothetical Reference Digital Link (HRDL). The exact length and composition in respect of the number, type and disposition of equipments will depend on the digital impairment under study. For example, in the analysis of jitter accumulation in a network both transmission systems and muldexes would need to be included to take account of the different jitter characteristics exhibited by such equipment types. In addition the HRDL can be regarded as a constituent element of an HRX thus permitting the apportionment of overall performance objectives to a shorter model. A length of 2500 km is considered as a suitable distance for a HRDL.

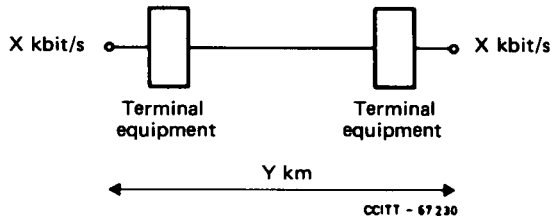
The formulation of such models is the subject of further study.

In CCIR Recommendations the term Hypothetical Reference Digital Path (HRDP) is sometimes used. This is equivalent to a Hypothetical Reference Digital Link (see Definition 3005 in Recommendation G.701).

4 Hypothetical reference digital section (HRDS)

To accommodate the performance specification of transmission systems (i.e. digital line and radio systems) it is necessary to introduce a Hypothetical Reference Digital Section (HRDS). Such a model is defined in Figure 4/G.801 for each level in the digital hierarchies defined in Recommendation G.702. The input and output ports are the recommended interfaces as given in Recommendation G.703 for hierarchical bit rates. The lengths have been chosen to be representative of digital sections likely to be encountered in real operational networks, and are sufficiently long to

permit a realistic performance specification for digital radio systems. The model is homogeneous in that it does not include other digital equipments such as multiplexers/demultiplexers. This entity can form a constituent element of a HRDL.



Note — The appropriate value for "Y" is dependent on the network application. For now the lengths of 50 km and 280 km have been identified as being necessary (see Recommendation G.921).

FIGURE 4/G.801

Hypothetical reference digital section

It is possible to relate the two following types of performance requirement to an HRDS:

- the Network Performance Objectives (NPO) which are the objectives to be realized in a real network;
- the Equipment Design Objectives (EDO) which provide guidance to the designer of systems using specific transmission media and transmission techniques.

Note 1 - The Equipment Design Objectives which normally appear in the appropriate transmission and switching system recommendations are formulated to ensure compatibility with the corresponding network performance objectives.

Note 2 - An explanation of a Network Performance Objective and an Equipment Design Objective is given in Recommendation G.102.

Note 3 - The formulation of a homogeneous entity of a realistic length permits specification and commissioning acceptance testing under real operational conditions.

In a similar manner CCIR and CMTT have formulated media and application orientated models for use in their studies. The following recommendations describe the relevant models.

- Recommendation 502-2 (Draft). Hypothetical Reference Circuit for Sound Programme Transmission. (Terrestrial systems and systems in the fixed-satellite service).
- Recommendation 521-1. Hypothetical Reference Digital Path for systems using digital transmission in the fixed-satellite service.
- Recommendation 556. Hypothetical Reference Digital Path for radio-relay systems for telephony.

ANNEX A

(to Recommendation G.801)

The application of Hypothetical Reference Models in the formulation of equipment design objectives

An important use of hypothetical reference models is to facilitate the apportionment of network performance

objectives to constituent elements, prior to the derivation of equipment design objectives. To satisfactorily achieve this objective a diagrammatic representation of the approach adopted by CCITT in the formulation of equipment design objectives is shown in Figure A-1/G.801.

The approach recognizes that it may be necessary to derive from the "standard HRX" a more appropriate HRX which better takes into account both the usage and the specific network performance parameter under study. The adoption of this approach will facilitate the formulation of rules governing the use of certain digital elements such as satellite links, transcoders, digital pads, etc.

National Administrations are advised to develop their own representative network models reflecting the features of their evolving national digital network in order to validate prima facie compliance with international standards.

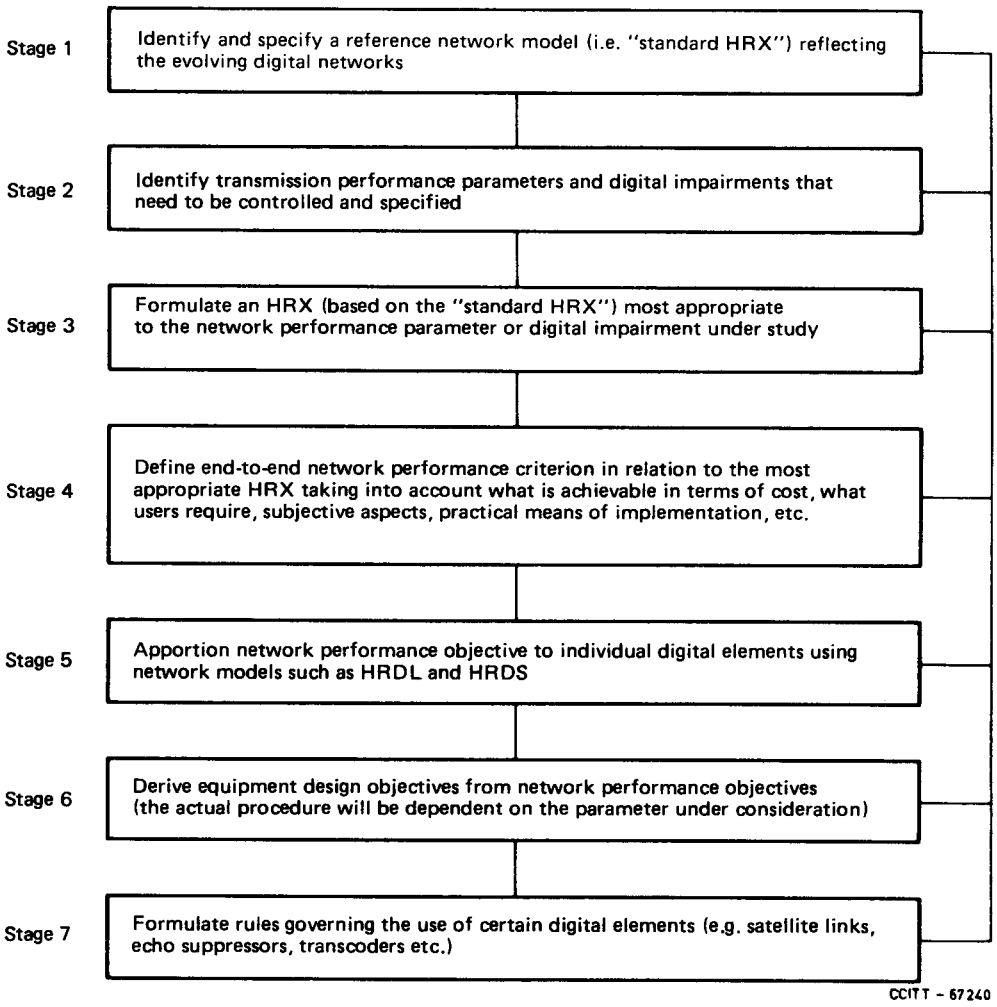


FIGURE A-1/G.801

The derivation of equipment design objectives based on the use of network models