INTERNATIONAL TELECOMMUNICATION UNION

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OF ITU

MAINTENANCE: INTERNATIONAL TRANSMISSION SYSTEMS (ANALOGUE)

TRANSMISSION RESTORATION AND TRANSMISSION ROUTE DIVERSITY: TERMINOLOGY AND GENERAL PRINCIPLES

ITU-T Recommendation M.495

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation M.495 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.495

TRANSMISSION RESTORATION AND TRANSMISSION ROUTE DIVERSITY: TERMINOLOGY AND GENERAL PRINCIPLES

1 Purpose of transmission restoration and transmission route diversity

The purpose of transmission restoration and transmission route diversity is to protect the continuity and quality of international telecommunication services by minimizing the effects of potential effects of a transmission failure.

This Recommendation applies to both analogue and digital transmission.

Note – This Recommendation may also apply in the case of hazardous conditions.

2 Causes of transmission failures

The causes of transmission failures can be divided into three major categories:

- equipment failure: this can be reduced by improving equipment reliability;
- outages due to the operating organization. For example, maintenance work or human errors;
- external causes which are very difficult to prevent and for which specific protection might be needed. For example weather conditions or excavation work.

In this Recommendation, failures or faults that are referred to may be either total or partial failures or faults. The relevant terminology concerning failures and faults can be found in Supplement No. 6 [1].

3 Definitions concerning transmission restoration and transmission route diversity

The purpose of this terminology is to define a vocabulary which can be used in connection with transmission restoration and transmission route diversity.

Note – In this terminology, the term "link" is used as a generic term for digital section, digital path, group link or section, supergroup link or section, mastergroup link or section, supermastergroup link or section, line section, section and line link.

3.1 *Basic concepts*

3.1.1 **transmission restoration**

The different actions taken in order to restore the transmission of a signal affected by a transmission fault.

3.1.2 **transmission restoration function**

The ability to perform under stated conditions and within given time constraints the transmission restoration.

Note 1 – This function is aimed at increasing the transmission availability; it can provide transmission link supervision and control, the sending and receiving of control and check signals, and the changeover from normal to an alternative link, if necessary by assembling links.

Note 2 – This function can allow the restoration of failed transmission systems, links, groups, digital blocks, equipment, etc., as well as the restoration for maintenance purposes such as planned outages, or to remedy conditions that affect transmission such as fading.

Note 3 – The transmission restoration function can be implemented by equipment that is dedicated to it, or by equipment that has other functions, such as, for example, automatic digital distribution frames.

3.1.3 **transmission restoration function: direct transmission restoration (protection link switching)**

Direct transmission restoration is that category of transmission restoration function in which one transmission link between two stations is substituted for another between those two stations.

Note – This reflects a configuration in which M links proctect N links, or in which N + M links give redundancy to a relation requiring N links, with the extremities of all links in the same locations. It is recommended to use the expression N + M direct transmission restoration to designate such a configuration. See Figure 1/M.495.

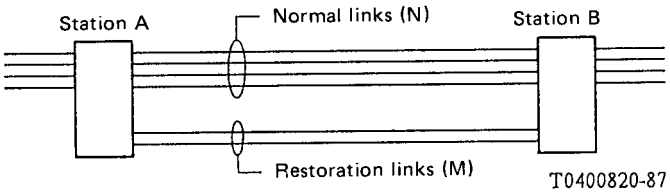


FIGURE 1/M.495

N + M direct transmission restoration system (protection link switching)

3.1.4 **transmission restoration function : automatic or semi-automatic transmission rerouting (protection network switching)**

Automatic or semi-automatic transmission rerouting is that category of transmission restoration function in which transmission links are assembled together and substituted for another link.

Note – This reflects a configuration in which a certain number of links form a restoration network and protect normal links. Within a given transmission station, or for a given switching equipment, M links protect N links. It is recommended to use the expression N + M automatic transmission rerouting to designate such a configuration.

Figure 2/M.495 shows an example. In Station A, M restoration links can be used for restoration of N normal. A link between A and B can be restored, for example, directly or via C.

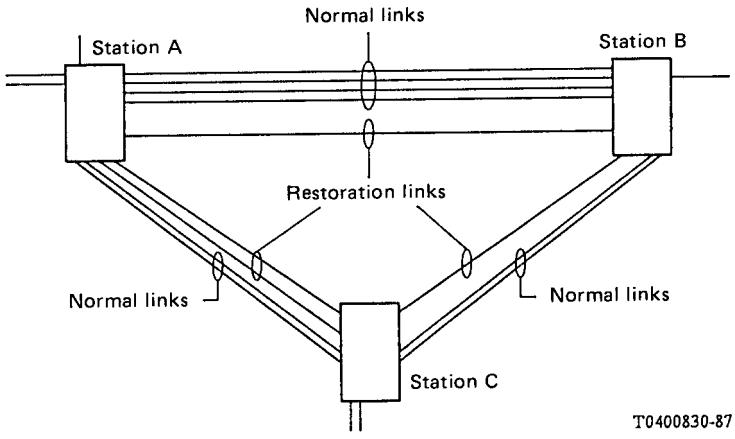


FIGURE 2/M.495

N + M automatic transmission rerouting system (protection network switching)

3.1.5 **transmission restoration function: 1 + 1 restoration**

1 + 1 restoration is that category of transmission restoration function in which one transmission link is substituted for another associated link, generally on another transmission route. See Figure 3/M.495.

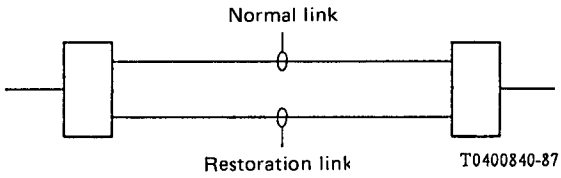


FIGURE 3/M.495

1 + 1 restoration system

3.1.6 **transmission restoration function: manual transmission rerouting**

Manual transmission rerouting is that category of transmission restoration function in which one transmission link is replaced manually by another when a complete or partial transmission route failure has occurred or when the normal route restoration link is not available due to a previous or simultaneous interruption, or when there is no such restoration link provided.

Note – Such rerouting is normally effected using plugs and cords.

3.1.7 **transmission restoration control function**

This is the function which decides whether restoration is necessary on the basis of information from the link supervision system or link alarms.

Note – The control function might be included in a specific equipment, or in the transmission restoration equipment itself, or within a restoration control centre. Control decisions can also be taken by people in, for example, a control centre.

3.2 *Systems and equipment*

3.2.1 **transmission restoration system**

A system that can be used to implement the transmission restoration function. An example is shown in Figure 4/M.495.

3.2.2 **transmission restoration equipment**

The part of the transmission restoration system that switches the transmission from the normal link to a restoration link.

3.2.3 **normal transmission link/equipment; normal digital block, group, supergroup, etc.**

A transmission link/equipment or a digital block, group, supergroup, etc., which is used for transmission under normal operating conditions.

3.2.4 **restoration link/equipment**

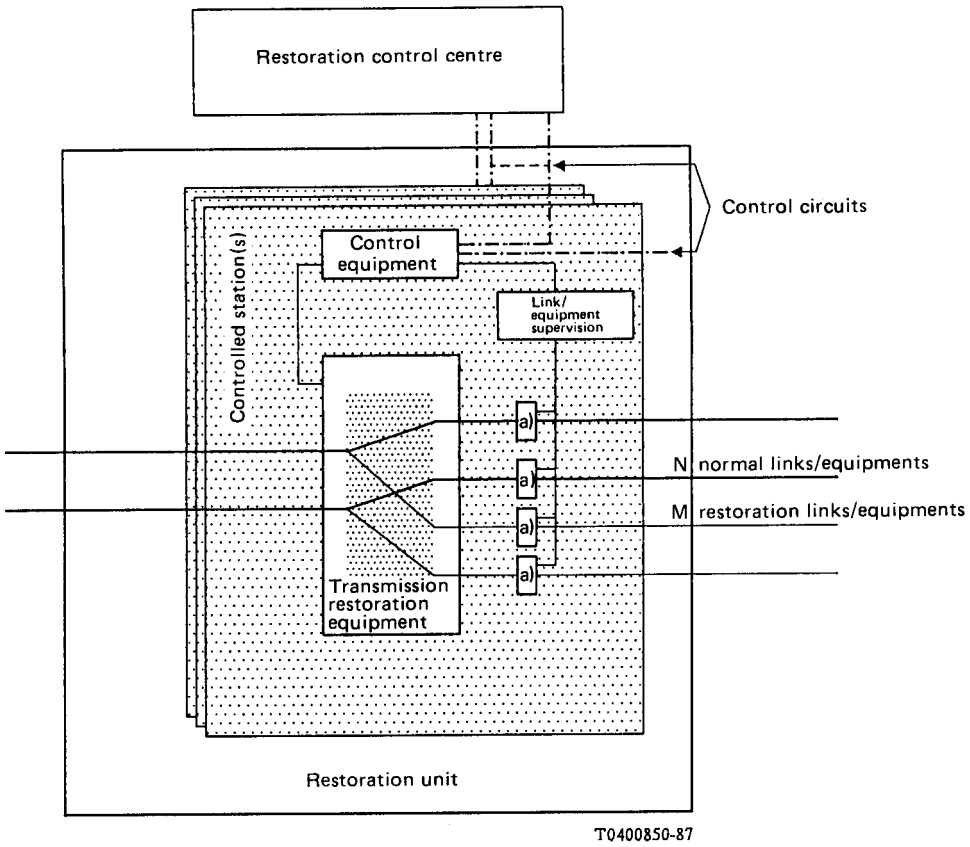
A transmission link/equipment which is used for transmission when the normal link/equipment is not available.

Note 1 – A restoration link or equipment is generally idle under normal operating conditions, but might be used under these conditions by low-priority traffic for which a lower degree of service availability is accepted.

Note 2 – Note 1 may not apply to 1 + 1 type restoration system where both links are carrying the traffic.

3.2.5 **restoration network**

The network formed by all restoration links.



a) Line terminal equipments and/or multiplex equipments

Note – This illustration is only an example. The structure of a transmission restoration system can be different (for example, the control function might be implemented within a restoration control centre, with no specific equipment).

FIGURE 4/M.495

Example of transmission restoration system

3.3 *Control* (see also Figure 5/M.495)

3.3.1 **control equipment**

An equipment that is used to implement the transmission restoration control function.

3.3.2 **restoration control centre**

A centre supervising all or part of normal and restoration transmission systems.

Note – A restoration control centre can be included within a control centre which is not dedicated to restoration.

3.3.3 **controlled station**

The station that has its systems, links and other maintenance elements supervised, where the information and commands for switching are sent to and received from, the control centre, and where the switching is effected.

3.3.4 **restoration unit**

All normal and restoration links and associated switching equipment capable of being controlled from a particular control centre.

Note – Some networks areas may be controlled from more than one control centre.

3.3.5 **control circuit**

A circuit used for the transmission of restoration control information.

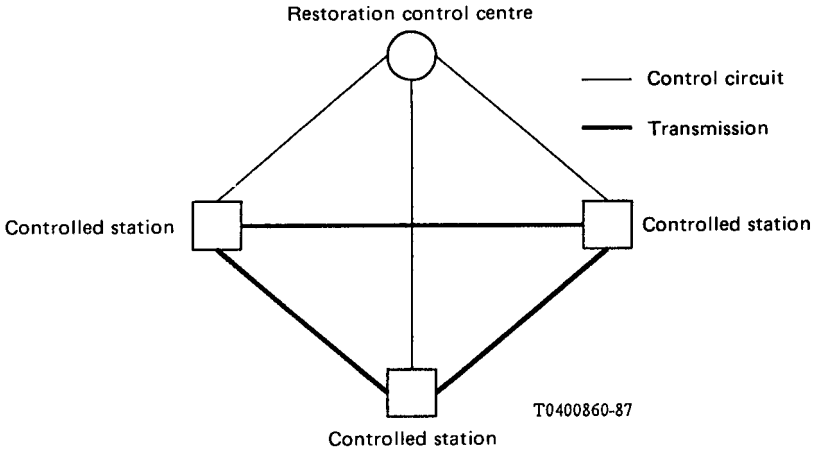


FIGURE 5/M.495

Restoration control

3.4 *Time intervals associated with transmission restoration processes*

The following time intervals are intended to describe the different time components between the failure of a signal and its restoration. These time intervals can be used to characterize those transmission restoration systems, equipment etc. See also figure 6/M.495.

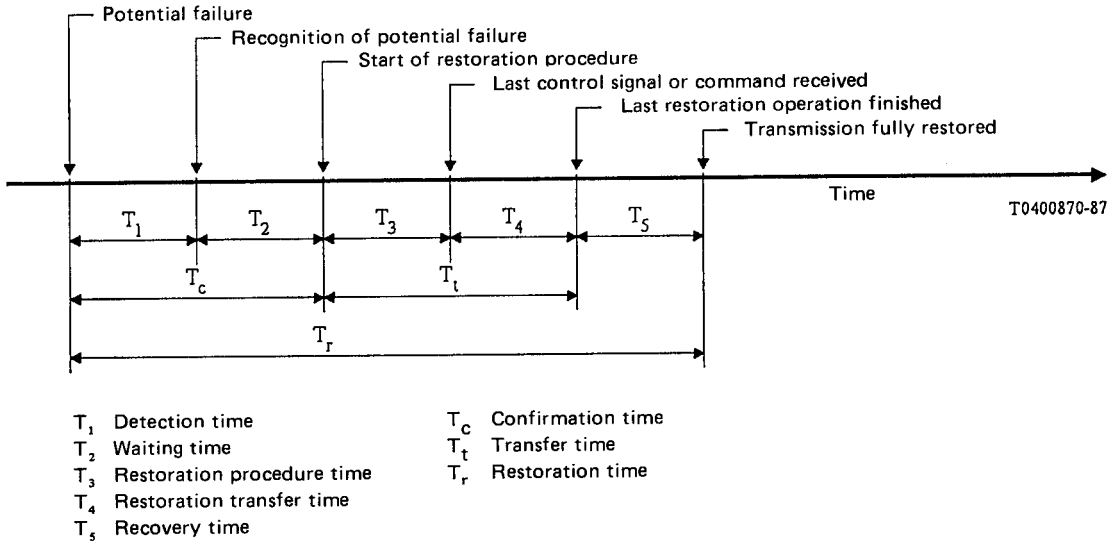


FIGURE 6/M.495

Defined restoration times

3.4.1 **detection time, T_1**

Time interval between a potential failure of transmission and the recognition of that potential failure.

3.4.2 **waiting time, T_2**

Time interval after the recognition of a potential failure and its confirmation as a fault requiring restoration.

3.4.3 **restoration procedure time, T_3**

Time interval between the confirmation of a fault and completion of the processing and transmission of the control signals required to effect restoration.

3.4.4 **restoration transfer time, T_4**

Time interval between completion of the processing and transmission of the control signals required to effect restoration and the completion of transmission restoration operations.

3.4.5 **recovery time, T_5**

Time interval between the completion of transmission restoration operations and the full restoration of failed transmission.

Note – This may include the verification of switching operations, re-synchronization of digital transmission, etc.

3.4.6 **confirmation time, T_c**

The time from the occurrence of the potencial failure to the instant when the fault is confirmed as requiring a restoration: $T_c = T_1 + T_2$.

3.4.7 **transfer time, T_t**

The time interval after the confirmation that a fault requires a restoration to the completion of the transmission restoration operation; $T_t = T_3 + T_4$.

3.4.8 **restoration time, T_r**

The time from the occurrence of the failure to the restoration of the faulty transmission:

$$T_r = T_1 + T_2 + T_3 + T_4 + T_5 = \text{confirmation time} + \text{transfer time} + T_5.$$

Note – An apparent fault might be detected by an equipment and not confirmed after the confirmation operations. In this case, only times T_1 and T_2 are relevant.

3.5 *Software related terms*

3.5.1 **network image**

Software description of the transmission network to be protected.

3.5.2 **fault definition program**

Program which collects fault information and defines faulty transmission links.

3.5.3 **restoration algorithm**

Method for forming restoration links for faulty normal transmission links.

3.5.4 **restoration control program**

A decision making program which controls restoration processes.

3.6 *Route diversity*

3.6.1 **transmission route**

A transmission facility on a specific medium used by a certain number of transmission systems between two stations.

Note 1 – For example, one cable between two stations could be regarded as one transmission route (whatever the number of systems using this cable might be) and a radio system between these two points could be regarded as an other route.

Note 2 – This definition represents a physical route; this is different from the term “route” which is defined in the Recommendations E.600 [2], Q.9 [3] and Z.341 [4], which represents a logical route.

3.6.2 **transmission route diversity**

The provision of at least two links between two nodes in a transmission network which are routed over different transmission routes.

Note – In case of a failure of one link, transmission route diversity allows some traffic between the two nodes still to be carried over the remaining link(s).

4 Principles of transmission restoration and transmission route diversity

4.1 *General principles*

4.1.1 In case of a fault of an international transmission system, complete and fast transmission restoration is a maintenance objective. Line and terminal equipment allocated for transmission restoration should be left available to the extent that the objective can be achieved. This equipment may sometimes be used for other purposes as required, e.g., planned outages.

4.1.2 When planning new routes or changes to existing routes, account should be taken of the requirements of restoration.

4.1.3 The responsibility for restoration should be based on the following principles in the case of an interruption due to a fault or to a planned outage of a transmission link:

a) when the fault of an international transmission link takes place on a national section, restoration is solely the affair of the Administration involved;

b) when a fault takes place on an international section of an international route, restoration is the affair of the Administrations of the two countries directly involved, even if Administrations of other countries are concerned;

c) in the case of a satellite fault, the responsibility to restore the satellite capability rests with the designated satellite system manager;

d) restoration should be effected in the transmission network at the highest order of link permitted by the network (group link, supergroup link, etc.) taking into account the service which is carried;

e) it would be desirable to arrive, if possible, at complete restoration based upon bilateral and/or multilateral agreements. Special consideration is necessary when, in practical cases, complete restoration cannot be achieved. When complete restoration is not possible the links to be restored should contain those circuits that satisfy the special needs of the Administrations involved to the extent possible. Sufficient restoration capacity should therefore be provided to reflect the special interests of each Administration involved. Certain services might be considered as priority services by bilateral agreements; in this case, they should be grouped on groups or digital blocks that are restored in priority;

f) in the case where it is not possible to restore all circuits through the procedures envisaged under a), b), and c), each terminal Administration should make the necessary agreements to use all available routes lending themselves to restoration.

4.2 *Transmission restoration systems*

The following points regarding transmission restoration systems should be noted:

a) in the case when a transmission restoration network exists, it might be used under normal operating conditions for preemptible traffic. However, the restoration time might be a little longer when low priority traffic has to be interrupted before the restoration;

b) transmission restoration systems might be used for specific maintenance purposes such as planned outages. In this case, a planned restoration should be effected in such a way that the resulting impact on tranmission quality and availability is minimized;

c) certain normal transmission links may have a priority restoration, with preemption on restoration links. On these links should be routed groups and digital blocks bearing services that are considered having priority;

d) in general, when the normal transmission link can be used again, transmission is switched back from the restoration link. This switch-back can be made manually, semi-automatically or automatically; it should be made in such a way that the resulting impact on transmission quality and availability is minimized;

e) in certain cases, restoration of transmission might be effected separately for the receive and transmit directions;

f) in case of automatic or semi-automatic restoration systems, there should be a possibility of manual action for a forced restoration or an inhibition. This action has to be possible semi-automatically for automatic restoration systems;

g) transmission restoration systems should be built in such a way that a fault of one of its components or a maintenance action on it will result, in most cases, in minimal impact on normal transmission quality and availability.

4.3 *Transmission route diversity*

Transmission route diversity is a way of protecting circuits groups (a number of circuits with the same terminal points) against the effects of transmission failures. Circuit groups are divided into smaller groups which are carried on different transmission routes. In this way, a transmission faults of one transmission route does not completely interrupt the service.

For example, 60 public circuits between two exchanges can be divided into 2 groups of 30 circuits routed on cable and radio link. See Figure 7/M.495.

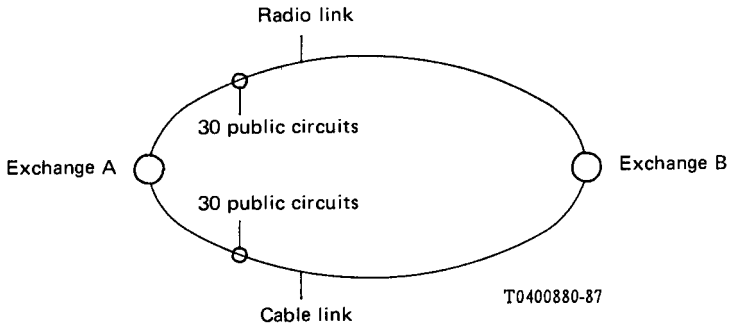


FIGURE 7/M.495

Diverse routing

4.4 *Restoration times*

4.4.1 It is useful to consider the restoration system in terms of the component time intervals involved. Some of these have been identified in the above terminology. These time intervals vary depending on whether the transmission system is analogue or digital. In the case of digital, the bit rate is also a factor.

4.4.2 It might be necessary, when specifying restoration times, and especially the confirmation time, to examine the different transmission restoration systems that might be used at the same time on a given link: for example, a 1 + 1 restoration system with its normal link beared by a transmission system protected by an N + 1 direct transmission restoration system.

4.4.3 The aim for restoration time performance objective will come from service interruption objectives which were currently under study by CCITT.

There might be different aims for various types of failure and of restoration type: single transmission system or complete transmission route failure; automatic, semi-automatic or manual restoration, etc.

4.5 *Restoration criteria*

The criteria used to decide if a restoration action is necessary can be based upon transmission fault and also occurrence of bad quality (signal-to-noise ratio for analogue transmission, bit error ratio, thresholds of Recommendation G.821 [5] for digital transmission, etc.).

5 Methods of transmission restoration

5.1 *General*

The links provided for transmission restoration can be used in the event of both faults and planned outages. Methods for restoration will necessarily vary according to the particular system and circumstances involved. They will include transmission restoration and physical repair using manual, semi-automatic or fully automatic methods. In order to choose the restoration method, it is appropriate for the Administrations involved to take into account the following elements in a bilateral or multilateral agreement:

a) the level of availability desired;

b) the facilities that may be used for restoration;

c) the economics related to the particular system being considered;

d) the compatibility of transmission equipment at appropriate locations (for example analogue/digital, satellite/coaxial etc.).

5.2 *Automatic restoration*

Automatic restoration is possible with the use of automatic restoration systems, which can be of three main types:

- 1 + 1 transmission restoration;
- direct transmission restoration (protection link switching);
- automatic transmission rerouting (protection network switching).

The functional organization of these restoration systems is described within Recommendation M.496.

5.3 *Semi-automatic restoration*

Specific equipment and transmission restoration systems are introduced in order to allow automatic restoration. As any interruption of service is undesirable, especially in the case of planned outages, this equipment should generally allow the remote manual activation and control of automatic transmission rerouting systems in order to change from the normal route to a previously set-up and tested restoration route.

5.4 *Manual restoration*

The complexity of the evolving international transmission network demands flexibility in any transmission restoration arrangement. In general, transmission restoration can be achieved by manual switching, for example on analogue or digital distribution frames. In this case a distribution frame is necessary. The links used for transmission restoration are arranged in a network configuration with particular restoration requirements being met by using such links either singly or connected in tandem. This arrangement is flexible and maximizes the use of international restoration links which are expensive to provide and therefore limited in number.

6 Considerations involved in planning transmission restoration systems

6.1 *Parameters to be taken into account:*

Restoration arrangements for transmission systems may be applied at any level in the multiplex hierarchy that is bilaterally or multilaterally agreed upon. The switching configuration itself may be a 1 + 1 or more complex N + M relationship, involving N normal links being protected by M restoration links. When planning a physical restoration system on an international basis the following considerations, among others, should be taken into account in the context of the desired availability and the economics involved.

a) availability of restoration capacity, taking into account the number of restoration and normal links;

b) transmission characteristics of the restoration link(s);

c) services to be restored and the acceptability of additional delay to confirm a fault and minimize switching (see § 4.4 of this Recommendation);

d) threshold at which fault is to be established (this may be adjustable in a range) (see § 4.5);

e) switching level in the multiplex hierarchy and whether any restorative switching is to be applied at more than one level;

f) manual or automatic switch-back techniques;

g) use of telemetry and control system, if required;

h) the need of a unidirectional or bidirectional system;

i) apportionment to the switches of the maximum degradation of the transmission characteristics (for example, maximum crosstalk, maximum unavailability . . .);

j) desirable restoration time (see § 4.4 of this Recommendation);

k) changed propagation time resulting from restoration over another route (this may be particularly important in the case of data transmission);

l) other functions that might be included in restoration equipment for maintenance purposes.

6.2 *Restoration network planning*

The restoration network should be dimensioned according to the objectives of the restoration capability for faulty transmission systems or equipment, as well as for planned outages.

One example of a method for dimensioning a restoration network without the help of simulation software is to add systematically a certain proportion of restoration links to the normal links.

Another method is to dimension the restoration network for the restoration of certain priority services in case of a single transmission route or transmission link fault. A priority protection for specific services would allow these services to have a better availability. This would allow the planning of a smaller and therefore cheaper restoration network that would be required for a systematic restoration of all transmission routes failures. The restoration network obtained in such a way would not only cost less in investment, but it would also serve to restore non-priority traffic when restoration links are available.

References

[1] CCITT Supplement *Terms and definitions for quality of service, network performance, dependability and trafficability studies*, Fascicle II.3, Supplement No. 6.

[2] CCITT Recommendation *Terms and definitions of teletraffic engineering*, Vol. II, Rec. E.600.

[3] CCITT Recommendation *Vocabulary of switching and signalling terms*, Vol. VI, Rec. Q.9.

[4] CCITT Recommendation *Glossary of terms*, Vol. VI, Rec. Z.341.

[5] CCITT Recommendation *Error performance of an international digital connection forming part of an Integrated Services Digital Network*, Vol.III, Rec. G.821.