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SERIES M: TMN AND NETWORK MAINTENANCE: INTERNATIONAL TRANSMISSION SYSTEMS, TELEPHONE CIRCUITS, TELEGRAPHY, FACSIMILE AND LEASED CIRCUITS

International transport network

Maintenance thresholds and procedures for recovery mechanisms (protection and restoration) of international SDH VC trails (paths) and multiplex sections

ITU-T Recommendation M.2102

(Formerly CCITT Recommendation)

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ITU-T Recommendation M.2102

Maintenance thresholds and procedures for recovery mechanisms (protection and restoration) of international SDH VC trails (paths) and multiplex sections

Summary

This ITU-T Recommendation defines maintenance thresholds and procedures for recovery mechanisms of international SDH VC trails (paths), multiplex sections (MSs) and subnetwork connections (SNCs), in case of failure, degradation, maintenance activities (e.g. planned outages).

This Recommendation deals with protection and restoration including return to original configuration. The internal protection capabilities of network element (NE) hardware are outside the scope of this Recommendation.

Maintenance thresholds and procedures given in this Recommendation are only used for protection and restoration of VCs trails (path), multiplex sections and subnetwork connections (SNCs)[1].

Source

ITU-T Recommendation M.2102 was prepared by ITU-T Study Group 4 (1997-2000) and approved under the WTSC Resolution 1 procedure on 4 February 2000.

Keywords

Acceptable state, alternative trail (path), automatic protection (revertive), automatic protection (non-revertive), automatic restoration (revertive), automatic restoration (non-revertive), manual protection (revertive), manual protection (non-revertive), manual restoration (revertive), manual restoration (non-revertive), multiplex section, normal, normalization, VC trail (path), patch, protection, recovery initiation, recovery mechanism, re-routing trail, restoration, subnetwork connection, SDH, service trail, switch, working trail.

[1] For a definition of subnetwork connections, see ITU-T Recommendation G.803 [2].

FOREWORD

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ITU-T Recommendation M.2102

Maintenance thresholds and procedures for recovery mechanisms (protection and restoration) of international SDH VC trails (paths) and multiplex sections

1 Scope

This ITU-T Recommendation defines maintenance thresholds and procedures for protection and restoration of international SDH VC trails[2], multiplex sections and subnetwork connections in case of failure, degradation, maintenance activities (e.g. planned outages).

This ITU-T Recommendation deals with protection and restoration including return to the original configuration. The internal protection capabilities of network element hardware are outside the scope of this Recommendation.

Maintenance thresholds and procedures given in this Recommendation are only used for automatic protection and restoration of VC trails, multiplex sections and subnetwork connections.

ITU-T Recommendations M.2101 [7], M.2110 [8] and M.2120 [9] apply to international SDH VC trails and multiplex sections, prior to, during and following protection or restoration.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

[1] ITU-T Recommendation G.783 (1997), *Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks.*

[2] ITU-T Recommendation G.803 (2000), *Architectures of transport networks based on the synchronous digital hierarchy (SDH)*.

[3] ITU-T Recommendation G.805 (2000), *Generic functional architecture of transport networks*.

[4] ITU-T Recommendation G.841 (1998), *Types and characteristics of SDH network protection architectures*.

[5] ITU-T Recommendation G.842 (1997), *Interworking of SDH network protection architectures*.

[6] CCITT Recommendation M.20 (1992), *Maintenance philosophy for telecommunication networks*.

[7] ITU-T Recommendation M.2101 (2000), *Performance limits and objectives for bringing-into-service and maintenance of international SDH paths and multiplex sections*.

[8] ITU-T Recommendation M.2110 (1997), *Bringing-into-service of international PDH paths, sections and transmission systems and SDH paths and multiplex sections*.

[9] ITU-T Recommendation M.2120 (2000), *PDH path, section and transmission system and SDH path and multiplex section fault detection and localization procedures*.

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[2] Throughout this ITU-T Recommendation the terms "trail" and "trails" should be understood to read "trail (path)" and trails (paths) respectively.

[10] ITU-T Recommendation M. 2130 (2000), *Operational procedures for the maintenance of the transport network.*

3 Terms and definitions

This ITU-T Recommendation defines the following terms:

3.1 normal: Original configuration of VC trail, SNC or MS: sometimes referred to as "working trail" or "in-service trail."

3.2 alternative trail: Transmission capacity available for recovery purposes.

3.3 switching: The action of transferring transmission capacity between the normal and alternative trail, and vice-versa, using NE switching matrices.

3.4 re-routing: The actions required to divert VC trails or Multiplex Sections onto reserved transport network capacity, in the event of working trail failure or degradation.

3.5 acceptable state: Implies the trail is not degraded. See ITU-T Recommendation M.20 [6].

3.6 patching: The action of transferring transmission capacity manually between the normal and alternative trail, and vice-versa.

3.7 recovery mechanism: A mechanism by which transmission capacity can be recovered after a network failure or degradation. A recovery mechanism is defined by its actions, which are recovery initiation(s) and return(s) to the original configuration.

There are two types of recovery mechanisms: protection and restoration. Descriptions of recovery mechanisms are illustrated in Table 1 and Figure 1.

3.8 recovery initiation: The action which triggers the recovery mechanism. Each recovery mechanism has one or more possible recovery initiations. Examples of NE functions associated with recovery mechanism actions are: manual switching to the alternative trail which can be achieved using the G.783 [1] NE function "Manual Switch" and automatic switching to the alternative trail can be achieved using the G.783 [1] NE function "APS".

3.9 return to original configuration: The action which reverses network changes due to a recovery initiation. Each recovery mechanism has one or more possible returns to original configuration.

3.10 automatic protection (revertive): Recovery is initiated by automatic switching to the alternative trail; return to the original configuration is also automatic. The NE normally autonomously provides this functionality; the definitions from the NE perspective are given in ITU-T Recommendation G.783 [1].

Note that if a manual or forced switching to normal is provided to return to the original configuration, then the particular recovery mechanism is not considered to be automatic protection (revertive) for that particular action.

3.11 automatic protection (non-revertive): Recovery is initiated by automatic switching to the alternative trail; return to original configuration is done by forced or manual switching to normal.

3.12 manual protection: Recovery is initiated by forced or manual switching to the alternative trail; return to original configuration is done by forced or manual switching to normal.

3.13 automatic restoration (revertive): Recovery is initiated by automatic OS controlled switching to the alternative trail; return to original configuration is done by both automatic OS controlled switching to normal or manual switch to normal.

3.14 automatic restoration (non-revertive): Recovery is initiated by automatic OS controlled switching to the alternative trail; return to original configuration is done by manual switching.

3.15 manual restoration: Recovery is initiated by manual patching or manual switching to the alternative trail; return to original configuration is done by manual patching, manual switching or forced switching.

Table 1/M.2102 – Protection and restoration terminology

Recovery Mechanism	Recovery Initiation					Return to Original Configuration				
	Forced switching to alternative	**Automatic switching to alternative**	**Manual switching to alternative**	**Automatic OS controlled switching to alternative**	**Manual patching to alternative**	**Forced switching to normal**	**Automatic return to normal**	**Manual switching to normal**	**Automatic OS controlled switching to normal**	**Manual patching to normal**
Automatic protection (revertive)		X					X			
Automatic protection (non-revertive)		X				X		X		
Manual protection	X		X			X		X		
Automatic restoration (revertive)				X				X	X	
Automatic restoration (non-revertive)				X				X		
Manual restoration			X		X	X		X		X
NOTE – The table describes operational mechanisms. This table is not intended to specify equipment functionality.										

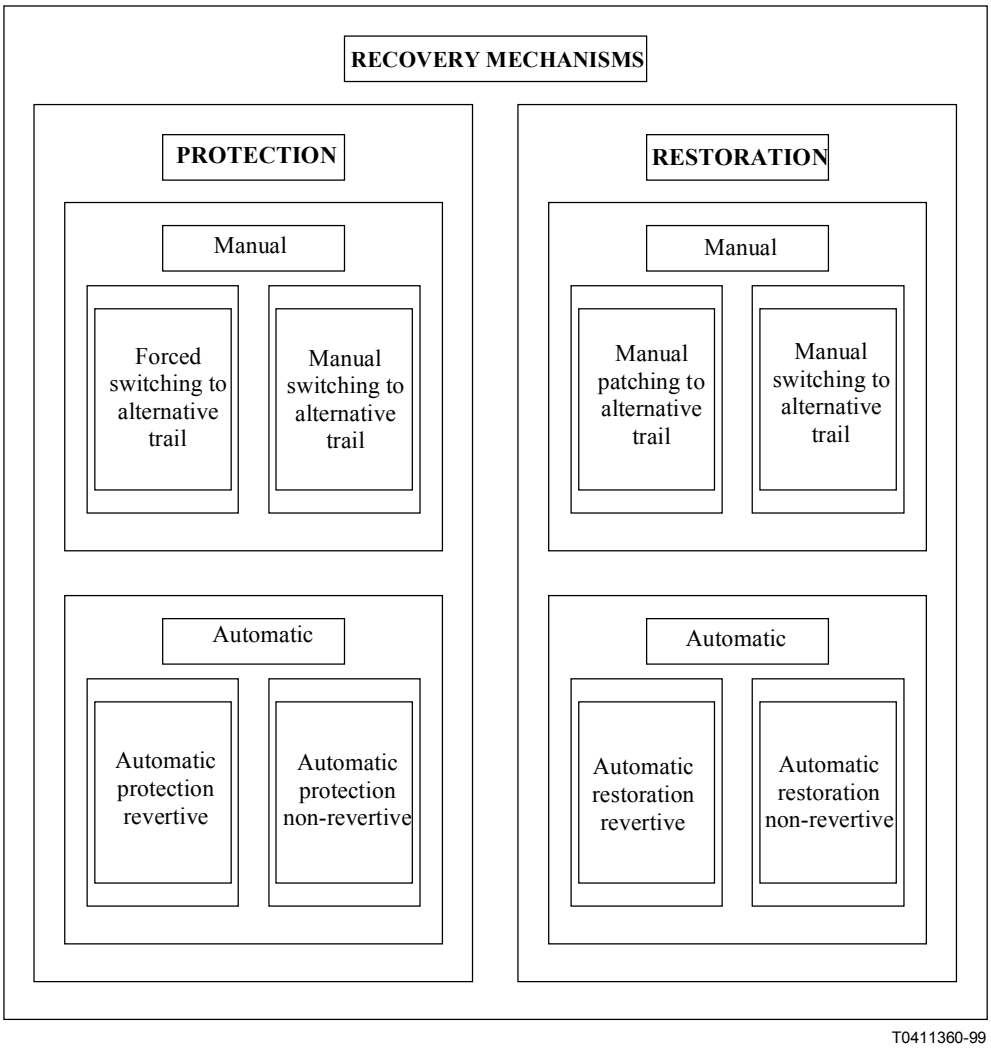

Figure 1/M.2102 – Recovery mechanism overview

4 Abbreviations

This ITU-T Recommendation uses the following abbreviations:

APS Automatic Protection Switching

ES Errored Second

HOPM Higher order Path Overhead Monitor

MS Multiplex Section

MSSPRING Multiplex Section Shared Protection Ring

NE Network Element

OS Operations System

SD Signal Degrade

SDH Synchronous Digital Hierarchy

SES Severely Errored Second

SF	Signal Fail
SNC	Sub-Network Connection
UAS	UnAvailable Second
VC	Virtual Container
WTR	Wait To Restore

5 Recovery mechanisms for international multiplex sections

This clause deals with recovery mechanisms for international SDH multiplex sections. See clause 6 concerning recovery mechanisms for SDH VC trails.

5.1 Multiplex section protection

5.1.1 Automatic switching to alternative MS

For automatic protection, there are two criteria, SD and SF, as defined in ITU-T Recommendation G.783 [1]. Network operators are responsible for bi- or multilateral agreement on the SD criterion per international multiplex section.

5.1.2 Forced switching to alternative MS

For maintenance activities, e.g. planned outages, operators may have to force switch the normal MS to the alternative MS (to ensure transmission continuity). It is recommended to use this procedure as a last resort only, due to the fact that a MS protection group[3] may carry several normal MSs, and in this case, the alternative MS will not be available for automatic protection (see Figure 2).

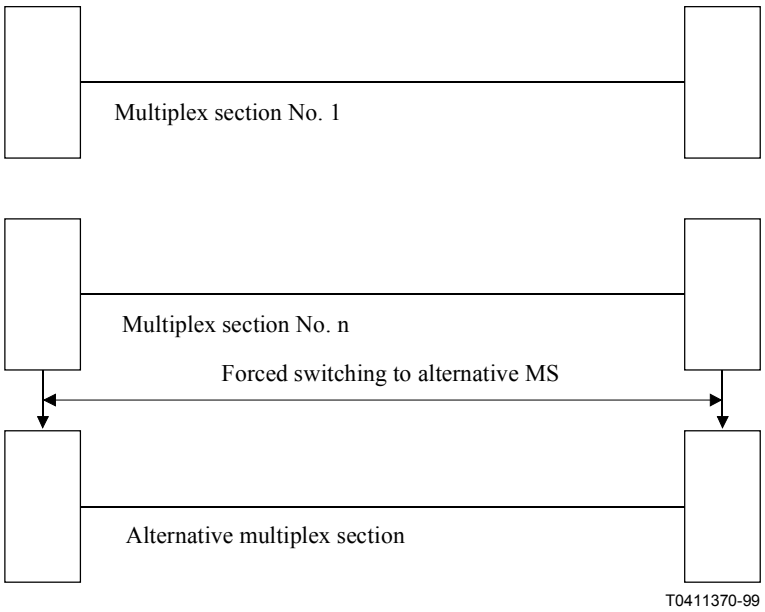

Figure 2/M.2102 – Forced switching to alternative MS for maintenance activities

[3] A MS protection group generally coincides with a submarine cable segment.

5.1.3 Switching time (automatic switching)

ITU-T Recommendation G.783 [1] specifies that automatic protection must be completed within 50 ms not including the detection window. This operation typically results in 1 or 2 SES.

When using a satellite connection or submarine cables, it may not be possible to meet the objective of 50 ms switching time (see ITU-T Recommendation G.783 [1]).

5.1.4 Criteria for automatic return to normal in the case of automatic protection (revertive)

Automatic return to normal is performed after an observation period without defects called Wait To Restore (WTR see ITU-T Recommendation G.783 [1]). This period of time begins when all the SD and SF conditions have been cleared.

5.2 Multiplex section restoration

For the purposes of this ITU-T Recommendation, MS restoration is not possible. VC trail recovery mechanisms may be used as described in 6.3.

MS restoration is for further study.

6 Recovery mechanisms for international connections in the SDH VC trail layer

This clause deals with recovery mechanisms for international VC-n trails. Protection and restoration can be applied to either unidirectional or bidirectional VC trails. Protection and restoration can be applied to VC trails, network connections and subnetwork connections. In the case of a unidirectional VC trail, only a single direction of transmission is present. Therefore, unidirectional recovery is the only solution.

In the case of a bidirectional VC trail, ITU-T Recommendations G.783 [1] and G.841 [4] define two options: unidirectional switching and bidirectional switching. However, unidirectional recovery should be carefully planned to ensure that delay imbalance between VC trail directions is not introduced.

See clause 5 concerning recovery for SDH multiplex sections.

6.1 Subnetwork connection recovery mechanisms

Subnetwork connection recovery is functionally defined in ITU-T Recommendation G.805 [3]. For the purpose of this ITU-T Recommendation, MSSPRING is considered to be a form of SNC recovery mechanism.

NE capabilities for SNC recovery mechanisms are defined in ITU-T Recommendations G.783 [1], G.841 [4] and G.842 [5].

SNC automatic protection is unidirectional (see Figure 3).

6.1.1 Automatic protection for subnetwork connections

SNC automatic protection provides the capability to recover portions of VC trails over several multiplex sections in tandem. Sometimes, significantly different routings for the alternative SNC are used.

Recovery initiation is performed by automatic switching to the alternative trail, based on SD and SF criteria as defined in ITU-T Recommendation G.783 [1]. Network operators are responsible for bi- or multilaterally agreeing to the SD criterion.

Return to the original configuration is performed by automatic return or forced switching to normal. Automatic return to normal is initiated after an observation period without defects (see WTR as

defined in ITU-T Recommendation G.783 [1]). This period of time begins when all SF and SD conditions have disappeared.

6.1.2 Manual protection for subnetwork connections

Recovery initiation is performed by manual or forced switching to the alternative trail, criteria are the responsibility of network operators by bi- or multilateral agreement.

Return to original configuration is performed by manual or forced switching to normal, criteria for which are the responsibility of network operators by bi- or multilateral agreement.

6.1.3 Subnetwork connection recovery times

Automatic recovery times are defined in ITU-T Recommendation G.841 [4].

Manual recovery times are for bi- or multilateral agreement.

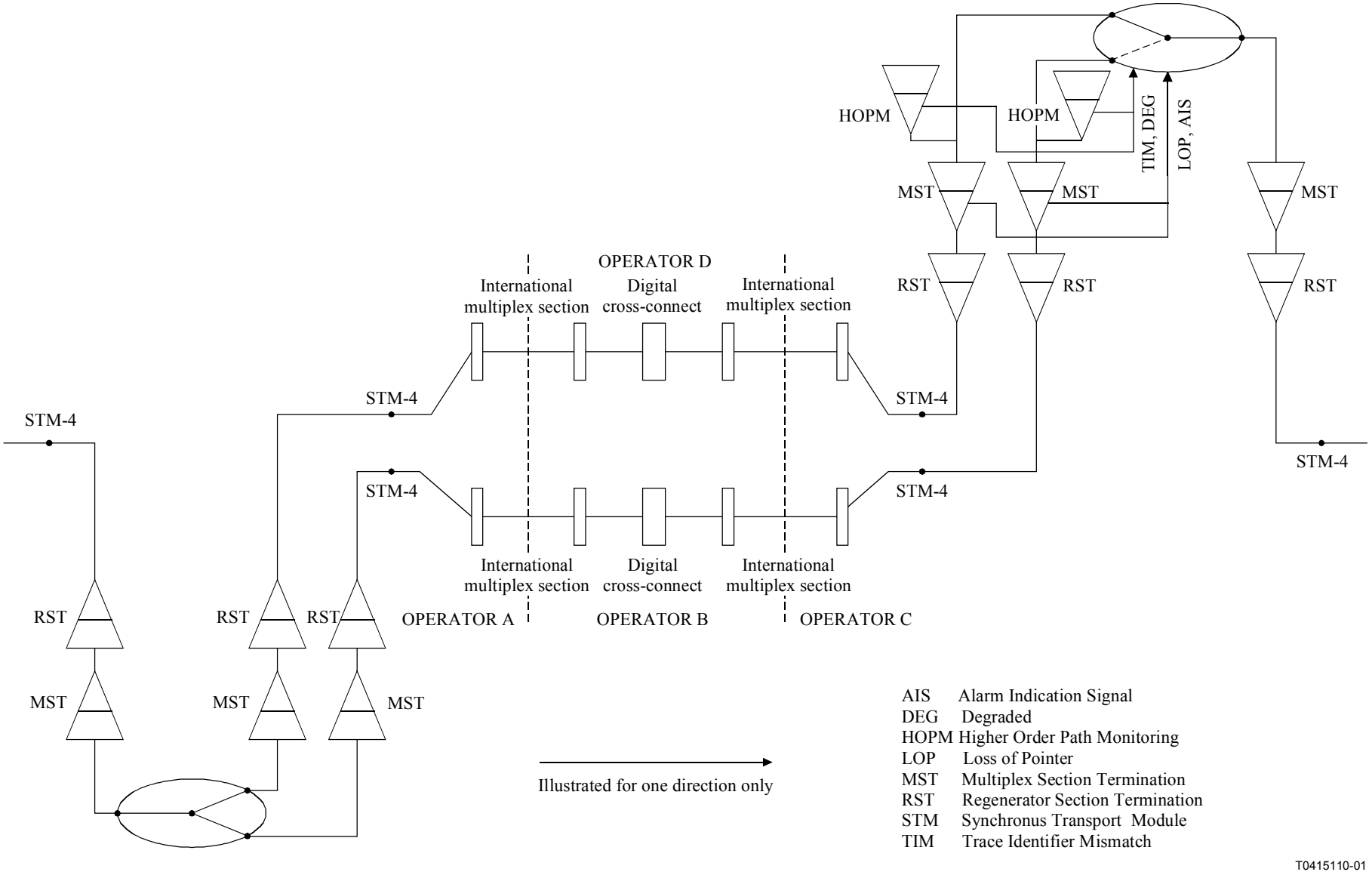

Figure 3/M.2102 – 1+1 automatic protection for subnetwork connection

6.2 VC trail recovery mechanisms

6.2.1 VC trail protection

Trail protection is functionally defined in ITU-T Recommendation G.805 [3] and NE capabilities for VC trail protection are defined in ITU-T Recommendations G.783 [1] and G.841 [4]. Recovery initiations are automatic or manual or forced switching to the alternative trail.

In the case of VC trail protection, ITU-T Recommendations G.783 [1] and G.841 [4] define unidirectional switching only. APS bandwidth is reserved in bytes K3 and K4 (bits 1 to 4 in a multiframe format).

Depending on bilateral agreements and capabilities of installed equipment, 1+1 protection is possible. It means sending the signal on two physically separated working trails at the same time, and switching between them at the receive side. In case of failure of either of the working trails, the payload connectivity thus remains. This method is particularly useful during maintenance activities such as planed outages (see Figure 4).

If a service requires a balance in transfer delay for both directions of transmission, the 1+1 VC trail protection should be operated in revertive operation mode. Most of the time, both directions of transmission will be routed via the same facilities. Only during a period with a fault in a single direction of the working trail, the two directions will be supported by different facilities.

For automatic protection, two parameters SD and SF are defined in ITU-T Recommendation G.783 [1].

Automatic return to the original configuration is initiated after an observation period without defects (see WTR as defined in ITU-T Recommendation G.783 [1]). This period of time begins when all SF and SD conditions have disappeared. This is not applicable to VC trail protection in non-revertive operation mode.

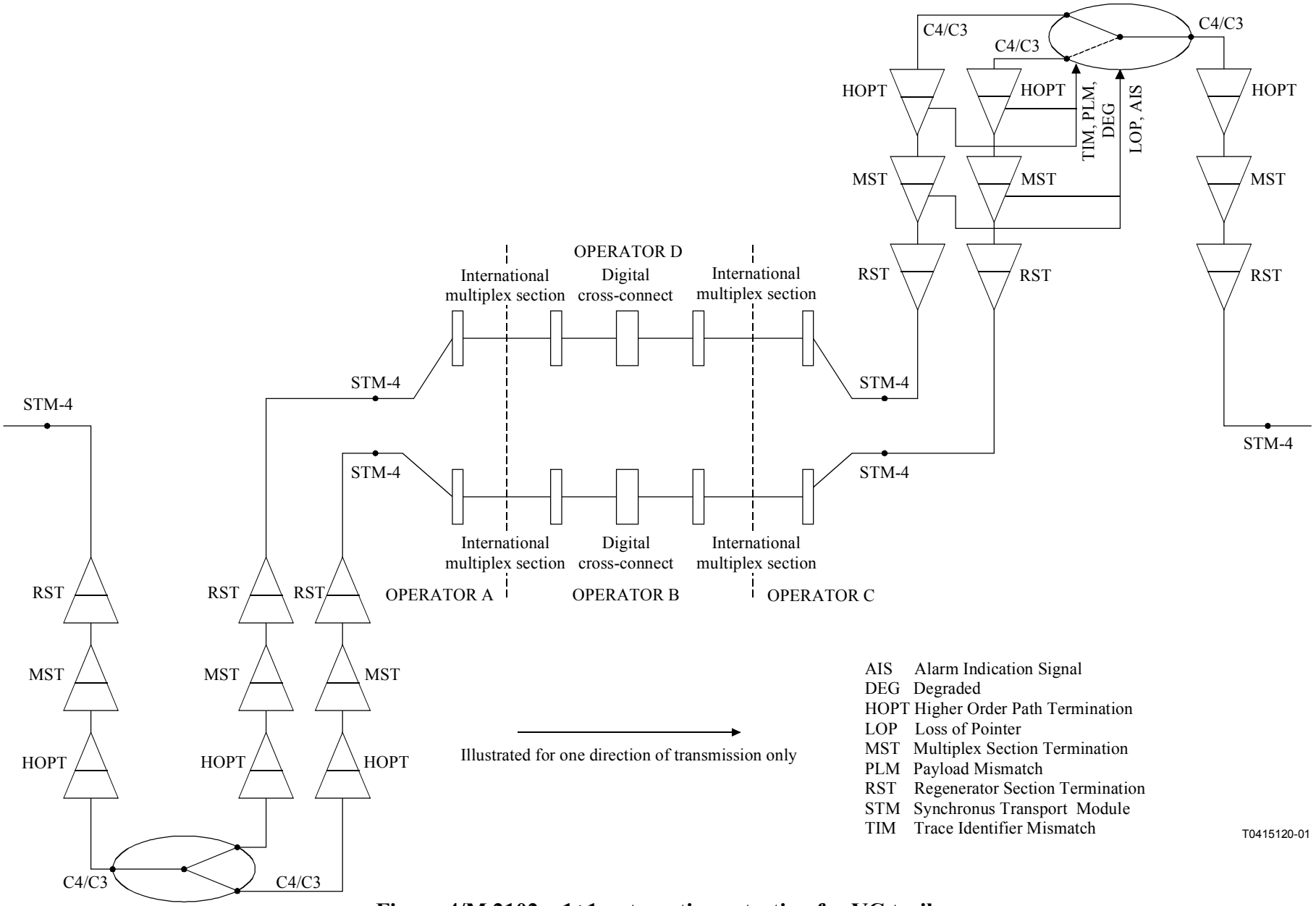

Figure 4/M.2102 – 1+1 automatic protection for VC trails

6.2.2 VC trail restoration

Restoration can be used when automatic protection cannot be carried out. In the case of a failure, transmission VC trail restoration is implemented by means of an international restoration plan negotiated within the respective working groups (examples: NSCC for North Sea submarine cables, ARC for transatlantic submarine cables, MEDRET for Mediterranean submarine cables, ERWG for European terrestrial links...). See Appendix I, Reference [1] for more information.

VC trail restoration may be initiated upon verification of a persistent fault or degradation on that VC trail. An ITU-T Recommendation providing details of the verification method is under development.

6.2.2.1 Manual restoration using digital cross-connect systems

For restoration, digital cross-connect systems offer a number of capabilities that could be exploited in order to improve the restoration process in case of a failure.

See Appendix II for a suggested method.

6.2.2.2 Return to the original configuration

To return to the original configuration, the network operators concerned shall follow ITU-T Recommendation M.2130 [10], in particular the network operators shall agree when to return to original configuration, to ensure minimal customer impact.

To indicate that the VC trail is ready to return to the original configuration, a signal is issued by the OS function, which controls the process. This signal shall be sent at the end of an observation period "d" (see Figure 5), if during this period all of the following conditions have been met: less than "n" ESs, no SESs, no UASs. The observation period starts when the OS receives the "failure cleared" report from the NE.

The value of "d", which is always greater than 15 minutes, is determined by bilateral or multilateral agreement and can be as great as 24 hours. The value of "n" for ESs will be defined in accordance with the "performance after repair" limits of ITU-T Recommendation M.2101 [7].

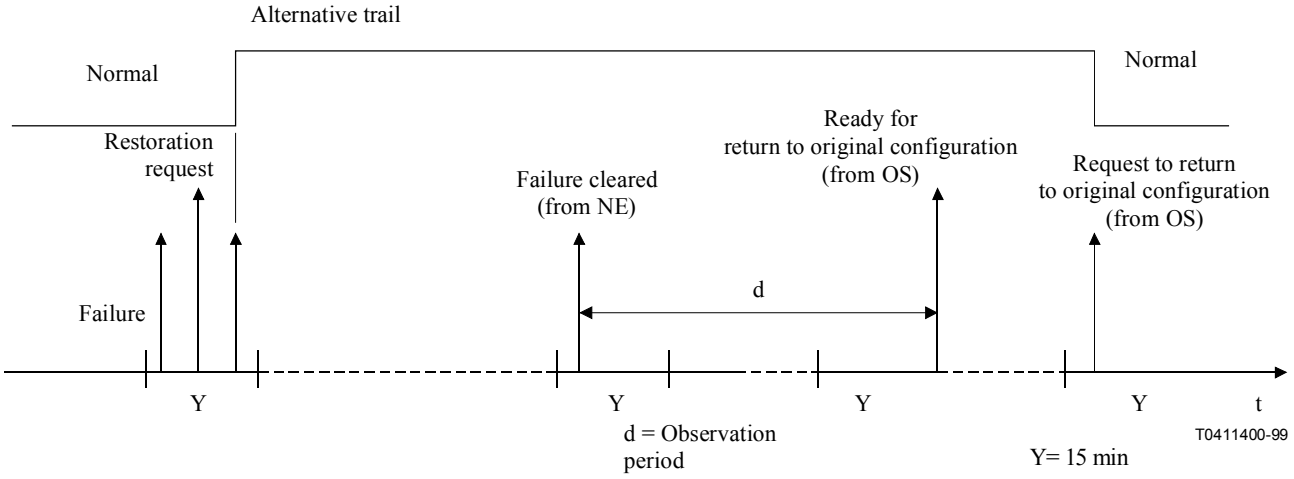

Figure 5/M.2102 – Return to original configuration process

6.2.3 VC trail recovery times

Restoration times are negotiated multilaterally between interested parties. Examples for negotiations can be found in Appendix I, Reference [1]. The recovery times are generally dependent on system configuration, availability of spare or pre-emptible capacity, and on the nature of the problem. It should be noted that as the international network develops, these times may change.

Completion of protection switching and hold-off times are defined in ITU-T Recommendation G.841 [4].

6.3 VC trail restoration during maintenance activities

The decision to perform a VC trail restoration for maintenance activities, e.g. planned outages, on the working trail, is left to the discretion of the operators concerned, the aim being to cause the least possible disturbance to the service. Before transfer, the restoration VC trail shall be acceptable from a performance point of view. Schedules for restoration procedures are to be established by common agreement between the operators concerned.

Concerning maintenance activities, e.g. planned outages, on an international VC trail within a national network, there should be no more than 2 SESs as a result of switching to restoration facilities.

Note that error extension across SDH section and VC trail layers is still under study. It might be necessary to specify different SES targets for different layers.

Additional information can be found in Appendix I, Reference [1].

See also Appendix II for a suggested method.

6.4 VC trail restoration exercises

Restoration exercises are important to ensure that restoration procedures are effective, examples of restoration exercises are given in Appendix I, Reference [1].

6.5 High priority and pre-emptible VC trails

It is desirable to have restoration procedures for high priority and pre-emptible VC trail restoration, examples can be found in Appendix I, Reference [1].

APPENDIX I

Bibliography

[1] URM – Universal Restoration Manual (latest edition). This document is distributed by co-owners on a system by system basis.

APPENDIX II

Manual restoration using Digital Cross-Connect Equipment

In order to expedite the manual restoration recovery mechanism, it may be possible to use the inherent capabilities of digital cross-connect systems

Recovery initiation:

1) When two International Network Operators provision a VC trail through digital cross-connect, an alternative trail may be configured between those nodes. However, this will have no configured association with any other VC trail.

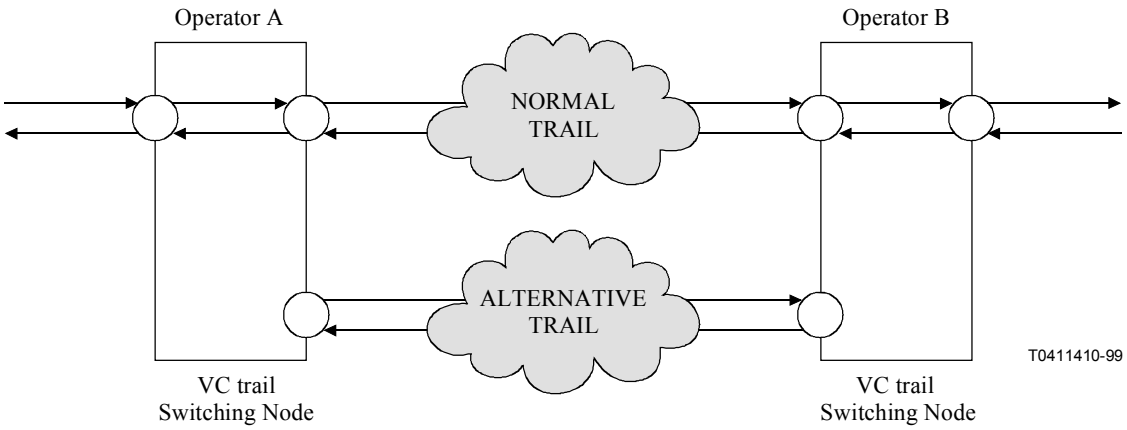

Figure II.1/M.2102 – Stand-by configuration

2) In the event of a failure or for planned outages on the normal trail, temporary SNC alternative trails should be established between the normal VC trail connection termination points and the alternative VC trail connection termination points. These temporary SNCs or alternative trails should be prepared in the case of planned maintenance activities. The VC trail is then dual fed down both the normal and alternate trails.

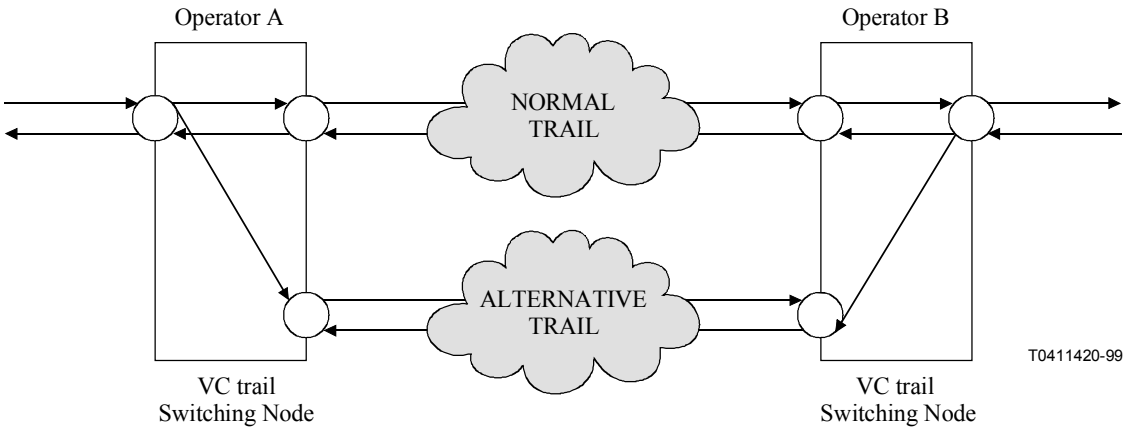

Figure II.2/M.2102 – Planned maintenance configuration

3) The transmission capacity received at the alternative VC trail connection termination points should be checked with regard to detection of the correct VC trail trace identifier using the Higher Order VC trail (path) Overhead Monitor (HOPM) or other method.

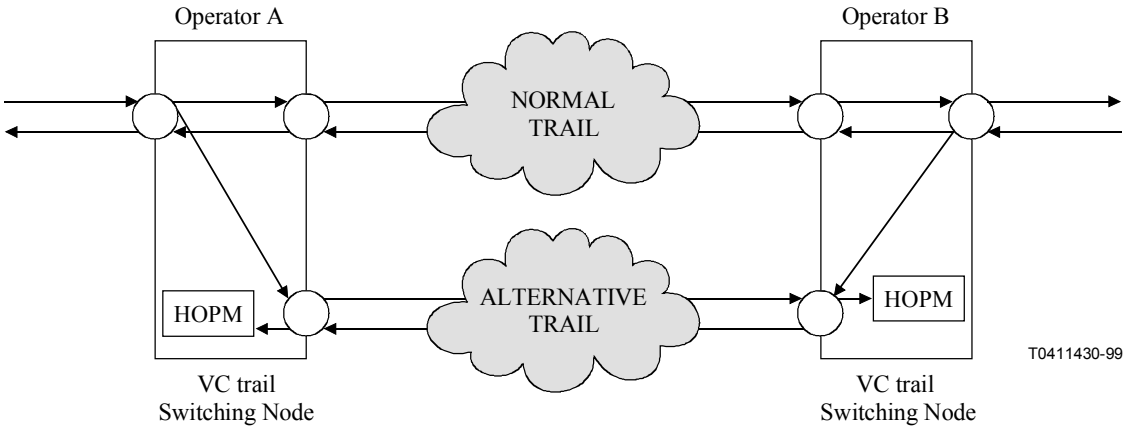

Figure II.3/M.2102 – Recovery configuration: control

4) Each receive end operator should then perform "manual switching to the alternative trail", using the NE's G.783 [1] "Manual Switch" function which is ranked below the G.783 [1] APS function, hence an operator cannot switch to a faulty trail.

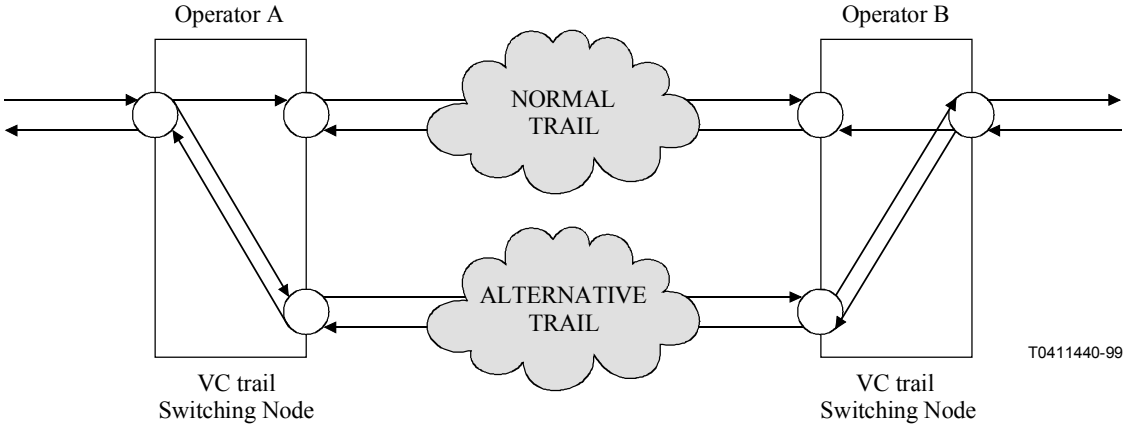

Figure II.4/M.2102 – Recovery configuration: implementation

5) Steps should be taken to ensure that reverting does not take place during maintenance activities.

Return to original configuration:

1) The transmission capacity received at the normal VC trail connection termination points should be checked with regard to detection of the correct VC trail trace identifier using the Higher Order VC trail (path) Overhead Monitor (HOPM) or other method.

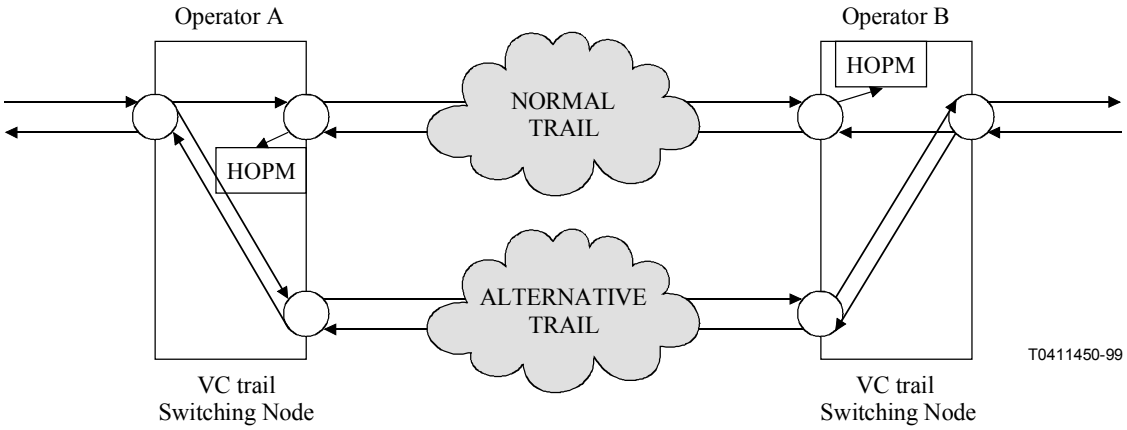

Figure II.5/M.2102 – Return to original configuration: control

2) Each receive end operator should perform "manual switched to normal " to return to original configuration. Again the operator cannot switch to a faulty trail.

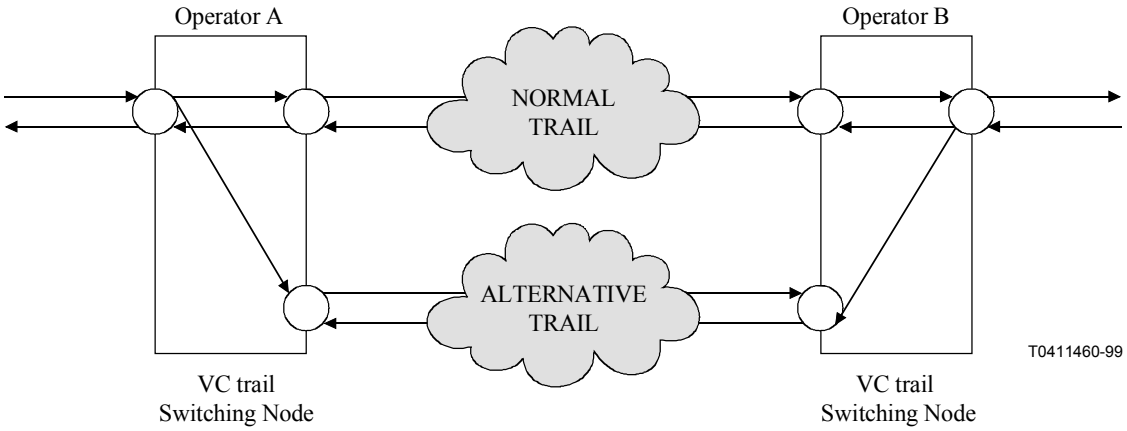

Figure II.6/M.2102 – Return to original configuration

3) The temporary SNC alternate trail is no longer required.

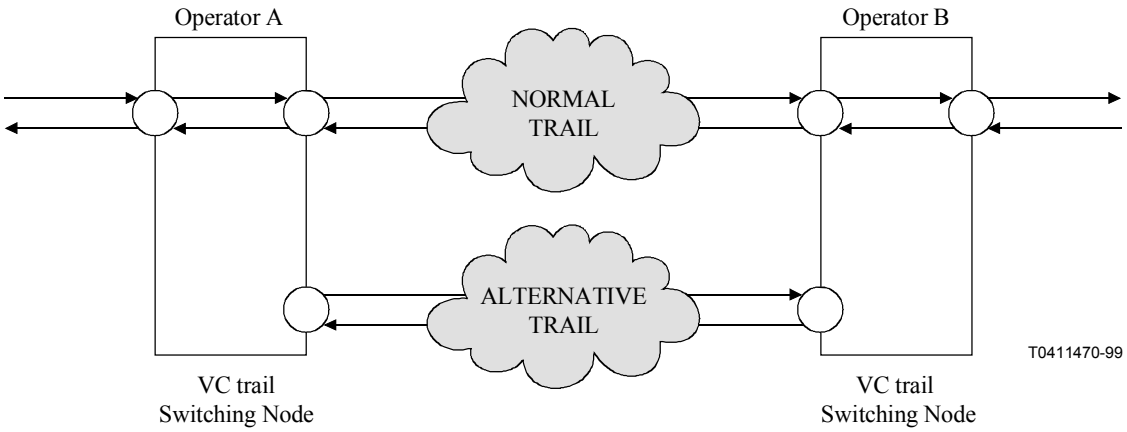

Figure II.7/M.2102 – Original stand-by configuration

The use of digital cross-connect systems capability proposed above would provide the following benefits:

a) It protects against an operator's mistake of switching to a faulty trail.

b) The network configuration can be partially established in advance to the recovery initiation.

c) The actual recovery initiation and return to original configuration by each operator can be undertaken with relative independence.

d) The disruption is minimized.

e) By use of the dual feed and the HOPM, the state of the alternative trail can be verified before activating the recovery mechanism.

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