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SERIES G: TRANSMISSION SYSTEMS AND MEDIA,  
DIGITAL SYSTEMS AND NETWORKS

Digital transmission systems – Digital networks – SDH  
network characteristics

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**Principles and guidelines for the integration of  
satellite and radio systems in SDH transport  
networks**

ITU-T Recommendation G.861

(Previously CCITT Recommendation)

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ITU-T G-SERIES RECOMMENDATIONS  
**TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS**

INTERNATIONAL TELEPHONE CONNECTIONS AND CIRCUITS	G.100–G.199
<b>INTERNATIONAL ANALOGUE CARRIER SYSTEM</b>	
GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS	G.200–G.299
INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES	G.300–G.399
GENERAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION WITH METALLIC LINES	G.400–G.449
<b>TRANSMISSION MEDIA CHARACTERISTICS</b>	
<b>DIGITAL TRANSMISSION SYSTEMS</b>	
TERMINAL EQUIPMENTS	G.700–G.799
DIGITAL NETWORKS	G.800–G.899
General aspects	G.800–G.809
Design objectives for digital networks	G.810–G.819
Quality and availability targets	G.820–G.829
Network capabilities and functions	G.830–G.839
<b>SDH network characteristics</b>	<b>G.840–G.899</b>
DIGITAL SECTIONS AND DIGITAL LINE SYSTEM	G.900–G.999

*For further details, please refer to ITU-T List of Recommendations.*

## **ITU-T RECOMMENDATION G.861**

### **PRINCIPLES AND GUIDELINES FOR THE INTEGRATION OF SATELLITE AND RADIO SYSTEMS IN SDH TRANSPORT NETWORKS**

#### **Summary**

This Recommendation provides guidelines and principles for the integration of digital radio-relay and satellite systems into SDH based transport networks. It focuses on the functional and architectural aspects of the integration from a network perspective, with the objective of ensuring compatibility in terms of the information transfer capability of SDH signal elements and inter-system management commonality. It does not consider the internal composition, or implementation specific details of digital radio-relay and satellite systems, which are the subject of the relevant ITU-R Recommendations.

#### **Source**

ITU-T Recommendation G.861 was prepared by ITU-T Study Group 13 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 27th of August 1996.

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## CONTENTS

	<b>Page</b>
1 Introduction.....	1
1.1 Scope.....	1
1.2 Structure of this Recommendation .....	1
1.3 References.....	1
1.4 Definitions .....	2
1.5 Abbreviations.....	3
2 Scenarios for radio digital section integration into SDH.....	4
2.1 Architecture description.....	4
2.2 Architectural principles.....	5
2.3 Digital sections at 51.84 Mbit/s and other sub-STM-1 bit rates.....	7
3 Satellite system as a wide-area SDH network node.....	7
3.1 Architecture description.....	7
3.2 Architectural principles.....	9
3.3 Examples of satellite-system based digital cross-connects.....	9
3.3.1 Wide-area cross-connect with various S-IOS rates .....	9
3.3.2 Wide-area cross-connect with 51.84 Mbit/s S-IOS .....	11
4 Guidelines for constructing sub-STM-1 multiplex structures and radio section layers	11
4.1 General.....	11
4.2 SDH multiplex conversion.....	11
4.3 Functions of radio section overhead (SOH).....	11
4.4 Media specific equipment interfaces (REI, SEI).....	13
5 SDH management aspects.....	13
5.1 Network layer management principles.....	13
5.2 General requirements .....	14
5.3 NE layer management facilities .....	14
5.4 Bandwidth efficiency .....	15
5.5 Management communications and interfaces.....	15



## **Recommendation G.861**

### **PRINCIPLES AND GUIDELINES FOR THE INTEGRATION OF SATELLITE AND RADIO SYSTEMS IN SDH TRANSPORT NETWORKS**

*(Geneva, 1996)*

## **1 Introduction**

### **1.1 Scope**

This Recommendation provides guidelines and principles for integrating digital radio-relay and satellite systems and equipment in SDH transport networks. It focuses on functional and architectural aspects of the integration from a G.803 network perspective. The objective is to ensure compatibility in terms of information transfer capability of SDH signal elements and inter-system management commonality.

A number of integration scenarios of radio/satellite systems with different roles and functions in the SDH transport network are described. They vary in transparency to G.707 synchronous transport module signals, or their payload (VCs) signals between the radio system interfaces.

This Recommendation addresses management aspects, including provision of and access requirements to SDH management facilities for radio and satellite systems in the G.784 SDH management subnetworks (SMS).

This Recommendation does not consider the internal composition, make-up and implementation specific details of the satellite and radio systems, which are the subject of pertinent ITU-R Recommendations.

### **1.2 Structure of this Recommendation**

Clause 2 describes scenarios and architectural principles for the integration of radio systems as point-to-point digital sections in SDH. Clause 3 describes a scenario for satellite systems emulating synchronous Network Element (NE) functions at SDH network nodes, and utilizes the satellite unique capability of supporting multipoint configurations to client connections of SDH elemental signal(s) (VCs or TUs). Clause 4 provides guidelines for constructing sub-STM-1 signal multiplex structures, new degenerate HOVC and direct mapping of LOVCs in sub-STM-1 radio sections. Clause 5 addresses SDH management aspects to be taken into account in multiple transmission media SDH systems.

### **1.3 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.

- ITU-R Recommendation F.750-2 (1995), *Architectures and functional aspects of radio-relay systems for SDH-based networks*.

- ITU-R Recommendation F.751-1 (1994), *Transmission characteristics and performance requirements of radio-relay systems for SDH-based networks.*
- CCITT Recommendation G.703 (1991), *Physical/electrical characteristics of hierarchical digital interfaces.*
- ITU-T Recommendation G.707 (1996), *Network node interface for the Synchronous Digital Hierarchy (SDH).*
- ITU-T Recommendation G.774 (1996), *Synchronous Digital Hierarchy (SDH) management information model for the network element view.*
- ITU-T Recommendation G.774.1 (1996), *Synchronous Digital Hierarchy (SDH) performance monitoring for the network element view.*
- ITU-T Recommendation G.774.2 (1996), *Synchronous Digital Hierarchy (SDH) configuration of the payload structure for the network element view.*
- ITU-T Recommendation G.774.3 (1996), *Synchronous Digital Hierarchy (SDH) management of multiplex-section protection for the network element view.*
- ITU-T Recommendation G.774.4 (1996), *Synchronous Digital Hierarchy (SDH) management of subnetwork connection protection for the network element view.*
- ITU-T Recommendation G.784 (1994), *Synchronous Digital Hierarchy management.*
- ITU-T Recommendation G.803 (1993), *Architectures of transport networks based on the Synchronous Digital Hierarchy (SDH).*
- ITU-T Recommendation G.831 (1996), *Management capabilities of transport networks based on the Synchronous Digital Hierarchy (SDH).*
- ITU-T Recommendation G.832 (1995), *Transport of SDH elements on PDH networks – Frame and multiplexing structures.*
- CCITT Recommendation M.1520 (1992), *Standardized information exchange between Administrations.*
- ITU-T Recommendation M.3010 (1996), *Principles for a telecommunications management network.*
- ITU-T Recommendation M.3020 (1995), *TMN interface specification methodology.*
- CCITT Recommendation M.3300 (1992), *TMN management capabilities presented at the F interface.*
- CCITT Recommendation X.722 (1992), *Information technology – Open Systems Interconnection – Structure of management information: Guidelines for the definition of managed objects.*
- ITU-R Recommendation S.1149 (1997), *Network architecture and equipment functional aspects of digital satellite systems in the FSS forming part of SDH transport networks.*

#### **1.4 Definitions**

This Recommendation defines the following terms.

**1.4.1 line termination (LT):** Access to both standard MSOH and RSOH.

**1.4.2 multiplex section (MS):** Access to standard RSOH and MSOH.

**1.4.3 network node interface (NNI):** The basic, fully standardized open interface in the SDH. The NNI is a physical interface and can be associated with an Intra-Office Section (IOS), which is



broadly equivalent to the existing G.703 interfaces. The basic description of the NNI is given in Figure 3-1/G.707.

**1.4.4 network node reference point (NNRP):** A reference point between the termination of an MS and an HOVC connection function, or between two directly connected MSs. The NNRP may or may not have an associated NNI.

**1.4.5 optical line interface (OLI):** An interconnection between optical line system regenerators and between optical line terminals and optical regenerators.

**1.4.6 optical line termination (OLT):** Access to both standard MSOH and RSOH.

**1.4.7 radio-relay air interface (RRAI):** An air interface between two radio terminals.

**1.4.8 radio-relay equipment interface (RREI):** An open interface between elements of the radio-relay system, which may either be electrical or optical.

**1.4.9 radio-relay line termination (RRLT):** A radio-relay line termination which may perform non-hierarchical MS signal generation (e.g. STM-N/51.84 Mbit/s conversion, G.832 SDH/PDH interworking equipment). Media specific additional section overhead functions may be defined across the associated RRRP or RREI.

**1.4.10 radio-relay reference point (RRRP):** The radio-relay equivalent of the NNRP, but internally defined between the radio-relay system equipment. The associated bit rate may be at sub-STM-1.

**1.4.11 satellite air interface (SAI):** An air interface between two satellite earth stations, and/or between the earth station and the satellite.

**1.4.12 satellite equipment interface (SEI):** An interface between elements of the satellite system, which may either be electrical or optical. The topology may be asymmetrical.

NOTE – SEI may or may not be an open interface.

**1.4.13 satellite line termination (SLT):** A satellite line termination which may perform non-hierarchical S-IOS signal generation (e.g. STM-N/51.84 Mbit/s conversion, G.832 SDH/PDH interworking equipment), and reconciliation of internal section and path asymmetric connection topologies. Media specific section overhead functions may be defined across the associated SRP or SEI.

**1.4.14 satellite reference point (SRP):** The satellite equivalent of the NNRP, but internally defined between the satellite earth station equipment. The associated bit rate may be at sub-STM-1. The topology may be asymmetrical.

**1.4.15 satellite regenerator terminal (SRT):** Terminal which broadly covers satellite modem and multiple access equipment.

## 1.5 Abbreviations

This Recommendation uses the following abbreviations.

DCC	Data Communication Channel
DXC	Digital Cross Connect
EI	Equipment Interface
HOVC	Higher Order Virtual Container
IOS	Intra-Office Section
LOVC	Lower Order Virtual Container

LT	Line Termination
MS	Multiplex Section
MSOH	Multiplex Section Overhead
NNI	Network Node Interface
NNRP	Network Node Reference Point
OLI	Optical Line Interface
OLT	Optical Line Termination
OR	Optical Regenerator
RRAI	Radio-Relay Air Interface
RREI	Radio-Relay Equipment Interface
RRLT	Radio-Relay Line Termination
RRRP	Radio-Relay reference Point
RRRT	Radio-Relay Regenerator Terminal
RS	Regenerator Section
RSOH	Regenerator Section Overhead
SAI	Satellite Air Interface
SDH	Synchronous Digital Hierarchy
SEI	Satellite Equipment Interface
S-IOS	Satellite Intra-Office Section
SLT	Satellite Line Termination
SOH	Section Overhead
SRP	Satellite Reference Point
SRT	Satellite Regenerator Terminal
SSTM-ij	Satellite Synchronous Transport Module level-ij
STM-N	Synchronous Transport Module level-N
TMN	Telecommunications Management Network

## **2 Scenarios for radio digital section integration into SDH**

### **2.1 Architecture description**

Integration scenarios of radio systems as digital sections between two SDH network nodes are illustrated in Figure 1. An MS with optical regenerators is depicted to show corresponding (or equivalent) functions of equipment items of the different systems. Examples of media-specific MSs (optical or radio-relay systems), as well as mixed-media (optical and satellite system) MSs are given.

These basic configurations can be applied to construct more complex network applications, such as multi and mixed-media protected MSs, closed multimedia rings of Add/Drop Multiplexers (ADMs) which are adding and dropping LOVCs.

## 2.2 Architectural principles

The following SDH architectural principles apply for the radio digital sections:

- i) Standard RSOH and MSOH functions defined in Recommendation G.707 should be supported. Further media specific functions may be added, using unused OH bytes, if available.
- ii) Radio systems may constitute either an MS (between NNIs) or an RS (between EIs) as part of an MS.
- iii) As an RS, basic RSOH functions described in Recommendation G.707 should be supported to give management commonality, and transparent transport of MS together with MS frame phase should be assured.
- iv) As an MS, basic SOH (RSOH and MSOH) functions described in Recommendation G.707 should be supported to give management commonality, and transparent transport of HOVCs and/or LOVC together with VC frame phase (TUs, TUGs) should be assured.
- v) The RREI and SEI must have their own OH and must be at least an RS with basic RSOH functions described in Recommendation G.707. They can transport an MS transparently, however they cannot carry an RS transparently. The same rules apply to RRAI and SAI.
- vi) If media specific OH bytes are added to the standard SOH, BIP-N needs to be recalculated at insertion and extraction points, or the additional bytes must have even parity.
- vii) Direct support of LOVCs in media-specific (lower bit rate) MS with new degenerate HOVC or non-standard TUG is allowed (e.g. through synchronous signal conversion/interworking functions performed in LT, RRLT or SLT), but this will restrict application in more complex structures.
- viii) Mixed media protection at MSs is feasible with compatible MSs and if there are no media specific MSOH functions. IOS cannot be used between the protection switch and the different line terminals.
- ix) Mixed media protection at HOVCs (and/or LOVCs) is feasible with dissimilar MS bit rates, and/or if media specific MSs are used. The different line terminals can be connected to the protection switch with IOSs.

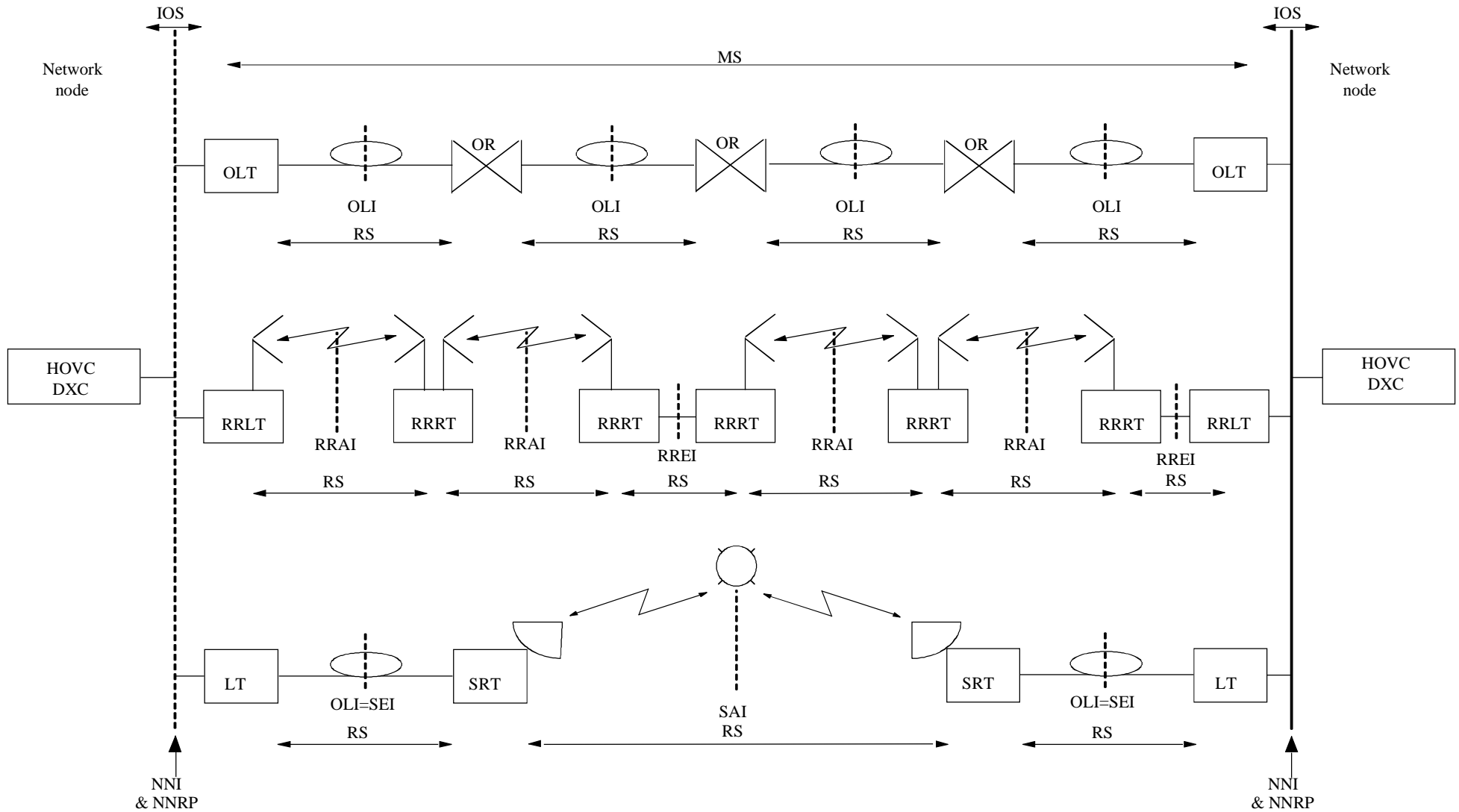


Figure 1/G.861 – Integration scenarios of radio and satellite digital sections in SDH transport network

### 2.3 Digital sections at 51.84 Mbit/s and other sub-STM-1 bit rates

Annex A/G.707 describes a 51.84 Mbit/s synchronous frame structure allowed for radio digital sections in SDH. This bit rate applies to system specific interfaces (RREI, SEI) and is not an NNI. The 51.84 Mbit/s synchronous radio frame structure is reproduced in Figure 2.

Transmission systems designed to carry PDH standard signals could readily support the transmission of SDH signal elements between SDH/PDH interworking multiplex equipment (an LT functionality) defined in Recommendation G.832.

## 3 Satellite system as a wide-area SDH network node

### 3.1 Architecture description

An integration scenario of satellite systems, performing the function of an SDH digital cross connect at a network node is illustrated in Figure 3. The internal system S-IOS (Satellite Intra-Office Section) is generally at a lower (sub-STM-1) bit rate and has a complex, multipoint topology. The associated asymmetry at each station is indicated by multiple SRTs.

The entire satellite system is functionally equivalent to an SDH HOVC/LOVC cross-connect equipment. The cross-connect function is geographically spread across a number of communicating satellite earth stations in the system. The internal system composition and efficient SDH signal element transmission are a matter for ITU-R standardization.

Application of this scenario is for the support of one or more LOVCs directly in S-IOSs, each sized to match the traffic carrying payload over the routes between communicating earth station pairs. The S-IOS sizing follows the multiplex conversion rules in 4.2.

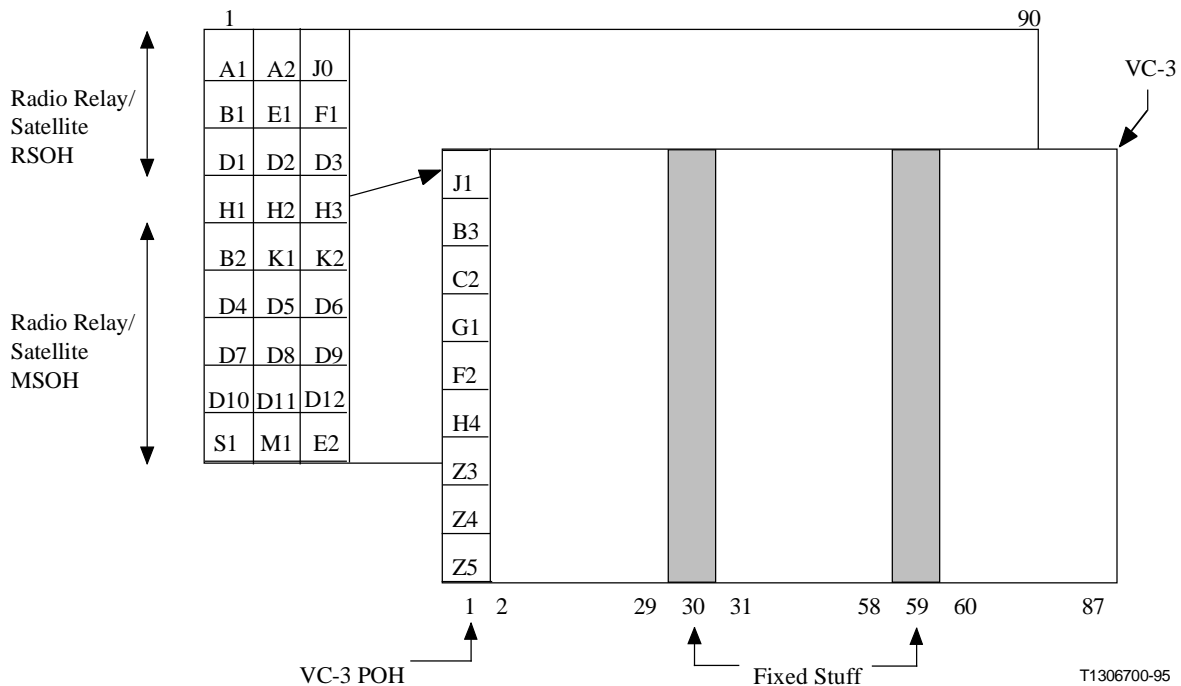


Figure 2/G.861 – Frame structure for 51.84 Mbit/s digital sections

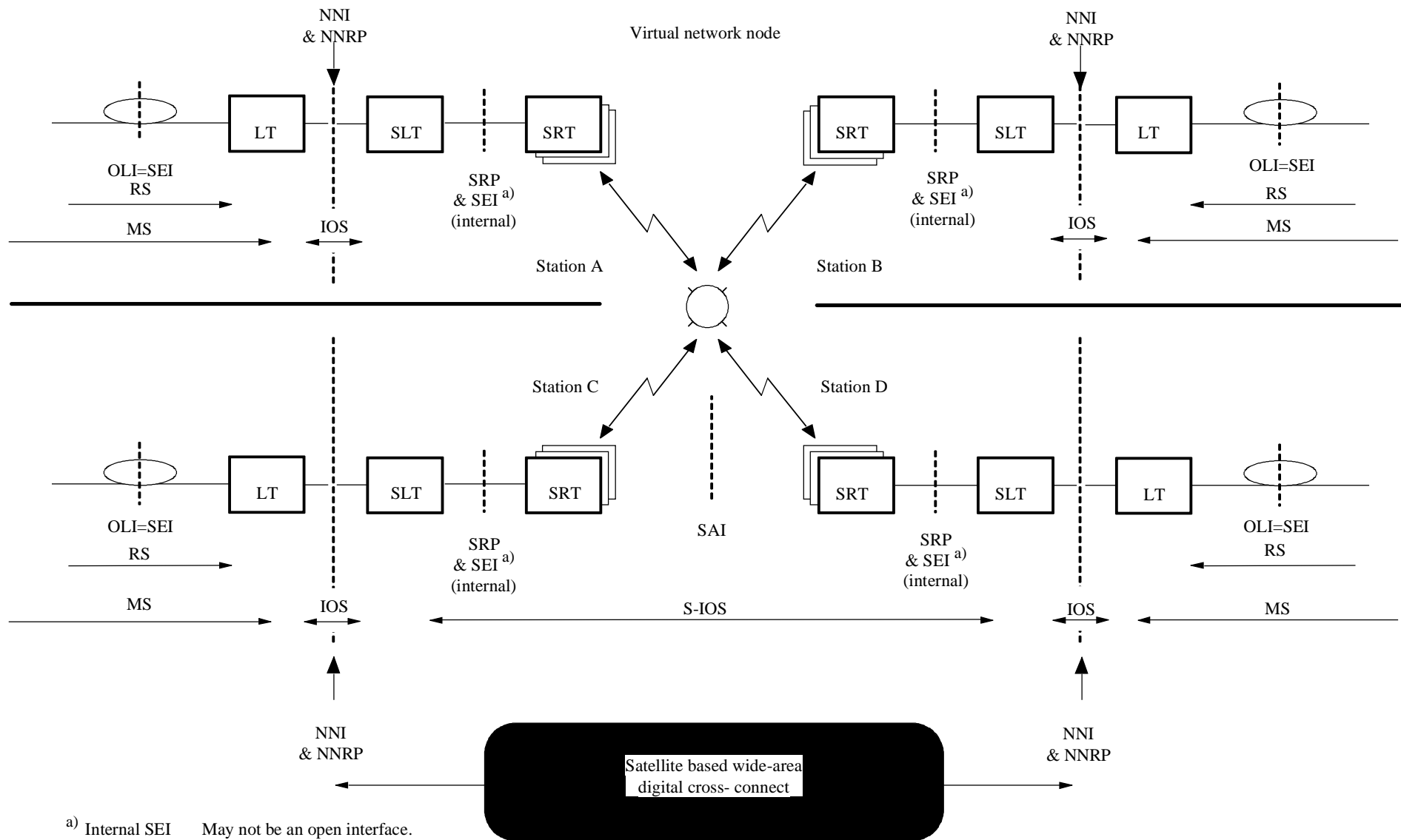


Figure 3/G.861 – Satellite system emulation of a cross-connect at an SDH network node

## 3.2 Architectural principles

The following SDH architectural principles apply for this satellite system scenario:

- i) The satellite system is functionally equivalent to synchronous Network Elements (NEs) at network nodes in the SDH network infrastructure.
- ii) The satellite system external interfaces should be compliant with SDH network node interfaces (Recommendation G.707) (STM-N).
- iii) The internal interfaces (SEIs) and S-IOS overhead functionality are specific to the satellite system. However, for management commonality the minimum OH functions given in Table 1 (4.3) should be supported.
- iv) The satellite system should ensure transparency to VC signal elements as a minimum.
- v) The satellite system should normally appear symmetrical when viewed externally, and capable of supporting bidirectional symmetric VC path connections.
- vi) Direct support of LOVCs in media-specific (lower bit rate) S-IOS with new degenerate HOVC or non-standard TUG is allowed (e.g. through synchronous signal conversion/interworking functions performed in SLT).
- vii) The multiplex functionality includes G.784-type management facilities, with internal system DCC capacity tailored to the satellite route size.
- viii) Any non-hierarchical section layers for synchronous transport of LOVCs or their integer multiples (TUGs) should be confined within the satellite system, and only partially visible from the external SDH transport network through management interfaces; the degree of visibility and accessibility for management control are for further study.
- ix) Asymmetrical connection topologies (unidirectional, bidirectional asymmetric, point-to-multipoint), satellite system efficient multidestination at S-IOS, and degenerate HOVC layers should be confined within the satellite system, and only partially visible from the external SDH transport network through management interfaces. Extension of multipoint topologies of client connections in the served path layer networks beyond the satellite system boundaries is for further study.

## 3.3 Examples of satellite-system based digital cross-connects

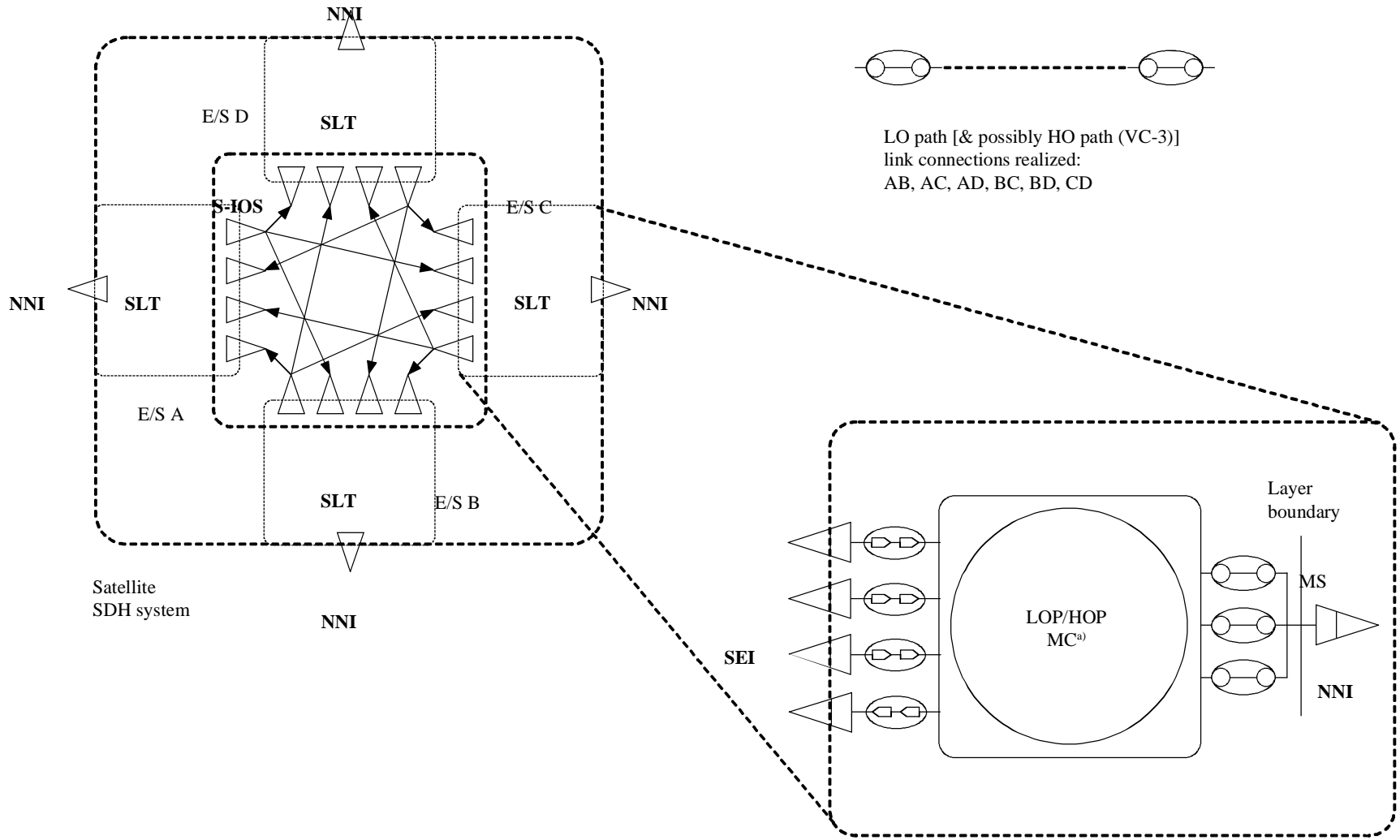
### 3.3.1 Wide-area cross-connect with various S-IOS rates

Figure 4 is a more detailed illustration of the point-multipoint satellite based cross-connect. The main application is for SDH thin satellite routes. Each individual thin route carries one, or a group of lower order signal elements (VC-12, TUG-2). These SDH signal elements are transported internally in an S-IOS frame structure, matched to the required traffic capacity on each route.

Asymmetrical connection topologies may be realized within the satellite based wide-area cross-connect at the internal S-IOS Layer and possibly internal path layers.

When viewed externally, the satellite system:

- terminates the regenerator and multiplex sections (STM-N) connections;
- terminates HO-Path (VC-3, VC4) connections;
- provides transparent point-to-point LO-Path through connections;
- may, in special cases, also be configured to terminate LO-Path connections and provide internal LO-Path asymmetric connections.



SEI Satellite Equipment Interface

<sup>a)</sup> Any asymmetry reconciliation.

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**Figure 4/G.861 – Wide-area satellite-based cross-connect with internal point-multipoint connection topology and sub-STM-1 section layer**

SDH demultiplex/remultiplex interworking is performed in the satellite system baseband equipment (SLT functionality). Guidelines and principles for the "interworking" multiplexing paths to extract SDH VC signal elements, or combinations thereof, are given in clause 4.



### 3.3.2 Wide-area cross-connect with 51.84 Mbit/s S-IOS

The same network view given in Figure 4 applies, except that all internal S-IOSs are at a single bit rate of 51.84 Mbit/s (STM-0). The possible application is "medium" satellite routes. The equipment for conversion between symmetrical STM-N NNIs to STM-0 (51.84 Mbit/s), possibly with asymmetrical SEIs is performed in the satellite system baseband equipment (SLT functionality). The multiplexer function includes G.784-type management facilities, with internal system DCC capacity available in the 51.84 Mbit/s SOH.

As an SDH cross-connect NE at a network node, the satellite system terminates regenerator and multiplex sections connections. If section termination is at STM-1, the satellite system:

- terminates HO-Path (VC-3, VC4) connections;
- provides transparent point-to-point LO-Path through connections;
- may, in special cases, also be configured to terminate LO-Path connections and provide internal LO-Path asymmetric connections.

If section termination is at STM-N, the satellite system may:

- provide transparent point-to-point LO-Path through connections;
- provide transparent point-to-point HO-Path through connections (requires internal STM-0 section layer parallel subnetworks);
- in special cases, also be configured to terminate HO-Path connections and provide internal HO-Path asymmetric connections.

## 4 Guidelines for constructing sub-STM-1 multiplex structures and radio section layers

### 4.1 General

The basic SDH signal elements to be transported are the various VCs with their associated pointers, adapted within radio and satellite synchronous section layers. As the pointer requirements depend on the radio system RRRT/SRT functions, its structure may be different from pointer structures utilized in standard SDH frame structures.

Management commonality is facilitated by the inclusion of selected SOH functions in the radio digital section. When a certain number of VCs and/or TUs are grouped together (degenerate HOVC), some overhead functionalities, if required, could be specified within the newly generated radio system paths. This is for further study.

### 4.2 SDH multiplex conversion

SDH standard signal elements/modules (TU-12, TUG-2, AU-3) should be used in defining the payload of new non-hierarchical radio section layers. The possible demultiplexing/remultiplexing (interworking) paths are indicated in Figure 5.

### 4.3 Functions of radio section overhead (SOH)

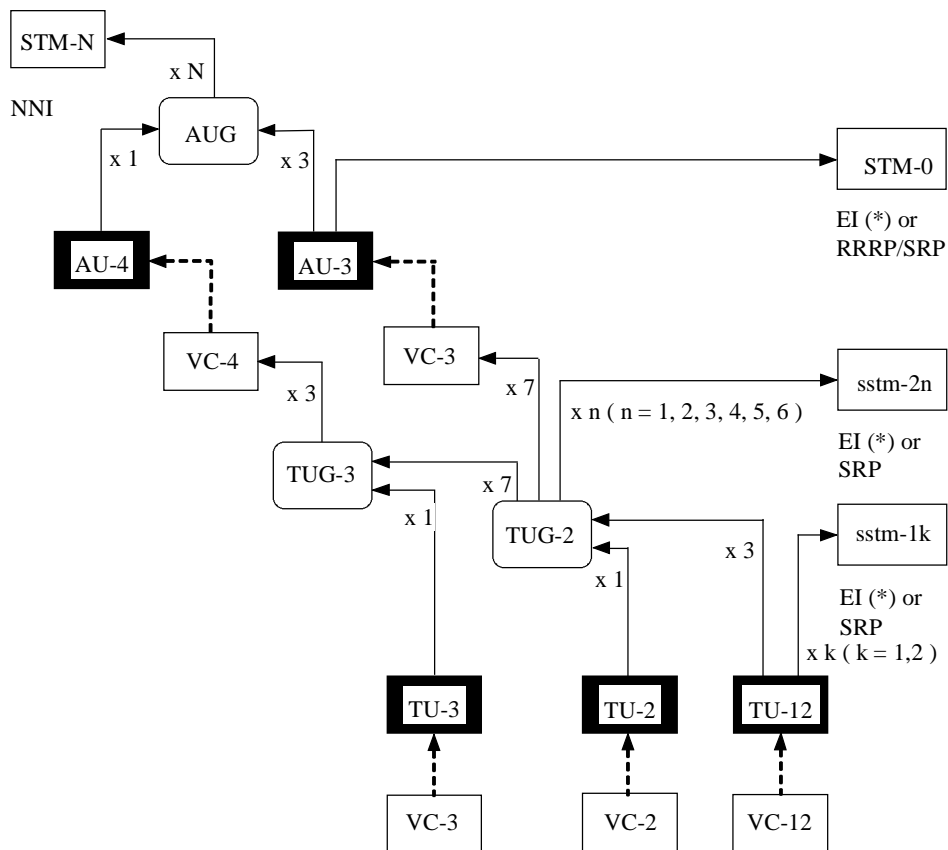
Efficient use of radio transmission bandwidth requires reduced SOH functionalities compared to the standard SDH SOH.

NOTE – Subclause 9.2.3/G.707 provides some guidelines for reduced SOH for intra-station interfaces.


As a minimum, the SOH functionalities identified as R (Required) in Table 1 should be accommodated in the radio sections. The byte allocation of radio SOH functions is a matter of ITU-R.


**Table 1/G.861 – List of functions to be implemented at the radio section level**

<b>Section OH function</b>		<b>Comments</b>
Frame Alignment Signal (FAS)	R	125 $\mu$ s frame reference is required
Section payload type	OP	Payload signal element/group indication
Trail trace	OP	Useful for complex IOS topologies
Section error monitoring	R	Used for generic section error monitor
Far end receive failure	R	FERF is required
Far end block error	R	FEBE is highly desirable
Data communication channel	R	Capacity depends on management needs and radio section bandwidth efficiency
Multipoint addressing	R	For backward indications
Order wire channel	OP	May be provided in RRRT/SRT
Other		For further study
R	Required	
OP	Optional	



 Pointer processing

 Multiplexing

 Aligning

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NOTE 1 – The need for an open Equipment Interface (EI) specification is an ITU-R matter.

NOTE 2 – Possible conversion routes:

STM/-N/AUG/AU-4/VC-4/TUG-3/TUG-2/TU-12/sstm-1k.

STM/-N/AUG/AU-4/VC-4/TUG-3/TUG-2/sstm-2n.

STM/-N/AUG/AU-4/VC-4/TUG-3/TUG-2/VC-3/AU-3/STM-0.

STM/-N/AUG/AU-3/STM-0.

**Figure 5/G.861– Demultiplexing/remultiplexing routes for constructing satellite and radio sub-STM-1 multiplex signals**

#### 4.4 Media specific equipment interfaces (REI, SEI)

The need for a radio section layer equipment interface (open) specification is an implementation matter.

### 5 SDH management aspects

#### 5.1 Network layer management principles

Network layer management principles are defined in Recommendation G.831.

## 5.2 General requirements

In mixed and multi-transmission-media SDH transport networks, inter-system and inter-operator management is facilitated by support of the mandatory SOH bytes across the NNI, and their associated functions as defined in Recommendation G.784, plus the provision of one or more management communication ports to give access to managed objects within the radio and/or satellite system.

Recommendation G.783 (1994) indicates the general relationship of management functions to SDH Network Elements, and Recommendation G.774 defines the management information model for SDH Network Elements and the managed objects found in cable transmission systems.

Radio and satellite systems should have management capabilities:

- a) to manage their SDH section and path connections and other internal functions;
- b) to provide a degree of management message processing capability (e.g. message filtering, routing, and partial DCC capacity);
- c) to provide partial and controlled access for external management systems to internal radio and satellite system functions and objects.

## 5.3 NE layer management facilities

SDH compatible radio and satellite systems should include SDH management facilities to meet the G.784 list of minimum management functions for single-ended SDH NE and inter-vendor network management communications. These are:

- fault management, performance management, configuration management, security management and general management communications functions.

Establishment of a degree of common management across mixed and multi-transmission-media SDH systems provided by multiple vendors but all based upon G.803 architecture involves:

- a) The adoption of a common information model for the network elements, i.e. adopting the requirements of Recommendation G.774 – "SDH Management Information Model for the Network Element view". Recommendation G.774 defines the managed objects and their associated attributes for SDH NEs. The guidelines for defining managed objects are described in Recommendation X.722 – "Guidelines for Definition of Managed Objects" GDMO.
- b) The adoption of common monitoring techniques using SDH error monitoring bytes (B1, B2) and the requirements of Recommendation G.774.1 – "SDH Performance Monitoring for the Network element View" to ensure uniformity of performance data characteristics being exchanged across SDH management domain boundaries.
- c) The adoption of the requirements of Recommendation G.774.2 – "SDH Configuration of the Payload Structure for the Network Element View".
- d) The adoption of the requirements of Recommendation G.774.3 – "SDH Management of Multiplex-Section Protection for the Network Element View".
- e) The adoption of the requirements of Recommendation G.774.4 – "SDH Management of Subnetwork Connection Protection for the Network Element View".
- f) The adoption of the message filtering, alarm threshold setting and integration periods functions to support performance monitoring detailed in Recommendation G.784 – "SDH Management".

#### **5.4 Bandwidth efficiency**

The management message communications capability, especially for the thin route satellite applications described in 3.3.1, should be a balance between the route size and the amount of essential management information requiring transport. To improve bandwidth efficiency over the satellite transmission medium, a statistical multiplexing technique may be employed to achieve efficient transport of management information together with other sporadic information via a single section overhead byte operating as a lower rate S-IO S DCC.

To reduce the bandwidth needed to support SDH on satellite systems generally it will be necessary to reduce the number of bytes carried by the SOH. Thus bytes which are not critical to the operation of SDH systems will possibly not be transported. This applies to the unallocated bytes and the national use bytes. Other bytes may be transported slightly more slowly as they may be carried on a serial channel rather than on their own dedicated byte.

#### **5.5 Management communications and interfaces**

For integration with TMN networks, the functionality of the communication ports provided for management communications on SDH equipment may be of the Q3 interface type as defined in Recommendations M.3010 – "Principles for a Telecommunications Management Network" and M.3020 – "TMN Interface Specification Methodology" or the X interface type as defined in Recommendation M.1520 – "Standardized Information Exchange between Administrations".

The implementation requirements of these interfaces are not defined.

For access by a management system which is fully integrated with the radio system then a proprietary interface may be employed. Several types of management interface may be provided on some pieces of equipment.

For access to management information by local staff, a TMN F type interface may be used as functionally defined in Recommendation M.3300 – "TMN Capabilities at the F Interface".

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