

# TR 101 035 V1.1.2 (1997-06)

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*Technical Report*

## **Transmission and Multiplexing (TM); Synchronous Digital Hierarchy (SDH) aspects regarding Digital Radio Relay Systems (DRRS)**

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*European Telecommunications Standards Institute*

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Reference

RTR/TM-04021A (9I000idg.PDF)

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Keywords

SDH, DRRS

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## Foreword

This Technical Report (TR) has been produced by the Transmission and Multiplexing (TM) Technical Committee of the European Telecommunications Standards Institute (ETSI).

The present document was originally published by TM as an internal document (TM TR 004), but since it has been found useful to refer to the content in other TM documents (standards and reports) it has been re-published as a TR. This has been done solely to make the content publicly available and no changes to the text have been made other than editorial changes.

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# 1 Scope

Future Digital Radio Relay Systems (DRRS) have to support the Synchronous Digital Hierarchy (SDH) defined by the ITU-T. Study Group (SG) 9 of the ITU-R in its final meeting in September 1989 approved a new report (ITU-R Report 1190 [3]) dealing with general aspects of DRRS in an SDH Network and containing a list of items which need further study.

Moreover, SG 9 has established Task Group (TG) 9/1 to study these very urgent aspects in the period between the meetings and to conclude its work before the next Interim Meeting of SG 9.

TG 9/1 ended its duty in 1992 producing ITU-R Recommendations F.750 [1] and F.751 [2].

It was deemed very important that the items listed in section 7 of ITU-R Report 1190 [3] will be carefully studied by TM4 as an urgent task and some clear statements produced.

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# 2 References

References may be made to:

- a) specific versions of publications (identified by date of publication, edition number, version number, etc.), in which case, subsequent revisions to the referenced document do not apply; or
- b) all versions up to and including the identified version (identified by "up to and including" before the version identity); or
- c) all versions subsequent to and including the identified version (identified by "onwards" following the version identity); or
- d) publications without mention of a specific version, in which case the latest version applies.

A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

- [1] ITU-R Recommendation F.750: "Architectures and functional aspects of radio-relay systems for SDH-based networks".
- [2] ITU-R Recommendation F.751: "Transmission characteristics and performance requirements of radio-relay systems for SDH-based networks".
- [3] ITU-R Report 1190: "Protection criteria for digital radio-relay systems to ensure compatibility with radar systems in the radio determination service".
- [4] ITU-T Recommendation G.707: "Network node interface for the synchronous digital hierarchy (SDH)".
- [5] ITU-T Recommendation I.150: "B-ISDN asynchronous transfer mode functional characteristics".
- [6] ITU-T Recommendation I.311: "B-ISDN general network aspects".
- [7] ITU-T Recommendation I.321: "B-ISDN protocol reference model and its application".
- [8] ITU-T Recommendation I.327: "B-ISDN functional architecture".
- [9] ITU-T Recommendation G.782: "Types and general characteristics of synchronous digital hierarchy (SDH) equipment".
- [10] ITU-T Recommendation G.783: "Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks".
- [11] ITU-T Recommendation G.958: "Digital line systems based on the synchronous digital hierarchy for use on optical fibre cables".

- [12] prETS 300 785: "Transmission and Multiplexing (TM); Synchronous Digital Hierarchy (SDH); SDH radio specific functional blocks for transmission of Mx sub-STM-1".
- [13] ITU-T Recommendation G.784: "Synchronous digital hierarchy (SDH) management".
- [14] ITU-T Recommendation G 702: "Digital hierarchy bit rates".
- [15] ITU-T Recommendation G.703: "Physical/electrical characteristics of hierarchical digital interfaces".
- [16] ETS 300 635: "Transmission and Multiplexing (TM); Synchronous Digital Hierarchy (SDH); Radio specific functional blocks for transmission of MxSTM-N".
- [17] ITU-T G.81x series of Recommendations:  
 ITU-T Recommendation G.811: "Timing requirements at the outputs of primary reference clocks suitable for plesiochronous operation of international digital links".  
 ITU-T Recommendation G.812: "Timing requirements at the outputs of slave clocks suitable for plesiochronous operation of international digital links".  
 ITU-T Recommendation G.813: "Timing characteristics of SDH equipment slave clocks (SEC)".
- [18] ITU-T Recommendation M.3010: "Principles for a Telecommunications management network".
- [19] ITU-R Recommendation F.596: "Interconnection of digital radio-relay systems".
- [20] ITU-T Recommendation G.781: "Structure of Recommendations on equipment for the synchronous digital hierarchy (SDH)".
- [21] ETS 300 147: "Transmission and Multiplexing (TM); Synchronous Digital Hierarchy (SDH) Multiplexing structure".
- [22] ETS 300 174: "Network Aspects (NA); Digital coding of component television signals for contribution quality applications in the range 34 - 45 Mbit/s".
- [23] ITU-T Recommendation G.957: "Optical interfaces for equipments and systems relating to the synchronous digital hierarchy".

## 3 Definitions and abbreviations

### 3.1 Definitions

For the purposes of the present document, the following definitions, relevant in the context of SDH-related Recommendations, apply:

**Administrative Unit (AU):** An AU is the information structure which provides adaptation between the higher order path layer and the multiplex section layer (see ITU-T Recommendation G.707 [4]).

**Administrative Unit Group (AUG):** An AUG consists of a homogeneous, byte interleaved assembly of AU-3s or AU-4s.

**Asynchronous Transfer Mode (ATM):** See ITU-T Recommendations I.150 [5], I.311 [6], I.321 [7] and I.327 [8].

**Bit Interleaved Parity (BIP):** BIP-X is a code defined as a method of error monitoring (see ITU-T Recommendation G.707 [4]).

**Container (C):** A container is the information structure which forms the network synchronous information payload for a VC (see ITU-T Recommendation G.707 [4]).

**Data Communication Channel (DCC):** See ITU-T Recommendation G.782 [9].

**Embedded Control Channel (ECC):** See ITU-T Recommendation G.782 [9].

**Higher Order Virtual Container (HOVC): VC-n (n = 3,4):** This element comprises either a single C-n ( $n = 3,4$ ) or an assembly of TUGs (TUG-2s or TUG-3s), together with the VC POH appropriate to that level.

**Higher order Path Adaptation (HPA):** The HPA function adapts a lower order VC (VC-1/2/3) to a higher order VC (VC-3/4) by processing the TU pointer which indicates the phase of the VC-1/2/3 POH relative to the VC-3/4 POH and assembling/disassembling the complete VC-3/4 (see ITU-T Recommendation G.783 [10]).

**Higher order Path Connection (HPC):** The HPC function provides for flexible assignment of higher order VCs (VC-3/4) within an STM-n signal (see ITU-T Recommendation G.783 [10]).

**Higher order Path Termination (HPT):** The HPT function terminates a higher order path by generating and adding the appropriate VC POH to the relevant container at the path source and removing the VC POH and reading it at the path sink (see ITU-T Recommendation G.783 [10]).

**Inter-office section:** See ITU-T Recommendation G.958 [11].

**Intra-Office Section (IOS):** See ITU-T Recommendations G.957 [23] and G.958 [11].

**Intra-Office Section Termination (IOST):** See ITU-T Recommendation G.958 [11].

**Intra-System Interface (ISI):** Interface with reduced SOH functionality (see ITU-T Recommendation G.707 [4]).

**Lower Order Virtual Container (LOVC): VC-n (n = 1,2):** This element comprises a single C-n ( $n = 1,2$ ) plus the lower order VC POH appropriate to that level.

**Lower order Path Adaptation (LPA):** The LPA function adapts a PDH signal to an SDH network by mapping/demapping the signal into/out of a synchronous container. If the signal is asynchronous, the mapping process will include bit level justification.

**Lower order Path Connection (LPC):** The LPC function provides for flexible assignment of lower order VCs in a higher order VC.

**Lower order Path Termination (LPT):** The LPT function terminates a lower order path by generating and adding the appropriate VC POH to the relevant container at the path source then removing the VC POH and reading it at the path sink.

**Message Communications Function (MCF):** See ITU-T Recommendations G.782 [9] and G.783 [10].

**Multiplex Section Adaptation (MSA):** The MSA function processes the AU-3/4 pointer to indicate the phase of the VC-3/4 POH relative to the STM-n SOH. Byte multiplexes the AU groups to construct the complete STM-n frame (see ITU-T Recommendation G.783 [10]).

**Multiplex Section Adaptation for sub-STM-1 Radio-Relay (MSA-RR):** See ETS 300 785 [12].

**Multiplex Section Overhead (MSOH):** MSOH comprises rows 5 to 9 of the SOH of the STM-n signal.

**Multiplex Section Protection (MSP):** The MSP function provides capability for branching the signal onto another line system for protection purposes (see ITU-T Recommendations G.782 [9] and G.783 [10]).

**Multiplex Section Termination (MST):** The MST function generates and adds rows 5 to 9 of the SOH (see ITU-T Recommendation G.783 [10]).

**Multiplex Section Termination for sub-STM-1 Radio-Relay (MST-RR):** See ETS 300 785 [12].

**Network Element (NE):** This is an element of SMS (see ITU-T Recommendation G.784 [13]).

**Network Node Interface (NNI):** See ITU-T Recommendation G.707 [4].

**Overhead Access (OHA):** The OHA function gives external interfaces to standardized SOH signals (see ITU-T Recommendation G.783 [10]).

**Path Overhead (POH):** The VC POH provides for integrity of communication between the points of assembly of a VC and its point of disassembly.

**Plesiochronous Digital Hierarchy (PDH):** See ITU-T Recommendations G.702 [14] and G.703 [15].

**Radio Complementary Section Overhead (RCSOH):** The transmission, in sub-STM-1 DRRS, as a well identified case of RFCOH, of a capacity equivalent to the 6 missed columns of a full STM-1 SOH format.

**Radio Frame Complementary Overhead (RFCOH):** The transmission capacity contained in the radio frame.

**Radio Overhead Access (ROHA):** The ROHA function gives external interfaces to radio specific SOH or RFCOH signals and gives suitable handling for the radio specific internal communication channels (see ETS 300 635 [16]).

**Radio Physical Interface (RPI):** Generic terminology for the typical radio-relay functions, including modulator, demodulator, transmitter, receiver, possible radio framer, etc.

**Radio Plesiochronous Physical Interface (RPPI):** A common description for the typical plesiochronous radio-relay functions, including modulator, demodulator, transmitter, receiver, possible radio framer, etc.

**Radio Protection Switching (RPS):** See ETS 300 635 [16] and ITU-R Recommendation F.750 [1].

**Radio-Relay Reference Point for sub-STM-1 radio-relay (RRRP):** See ITU-R Recommendation F.750 [1].

**Regenerator Section (RS):** A regenerator section is part of a line system between two regenerator section termination.

**Regenerator Section Overhead (RSOH):** The RSOH comprises rows 1 to 3 of the SOH of the STM-n signal.

**Radio Synchronous Physical Interface (RSPI):** A common description for the typical synchronous radio-relay functions, including modulator, demodulator, transmitter, receiver, possible radio framer, etc. (see ETS 300 635 [16]).

**Radio sub-STM-1 Synchronous Physical Interface (RsSPI):** A common description for the typical sub-STM-1 synchronous radio-relay functions, including modulator, demodulator, transmitter, receiver, possible radio framer, etc. (see ETS 300 785 [12]).

**Regenerator Section Termination (RST):** The RST function generates and adds rows 1 to 3 of the SOH; the STM-n signal is then scrambled except for row 1 of the SOH (see ITU-T Recommendation G.783 [10]).

**Regenerator Section Termination for sub-STM-1 Radio-Relay (RST-RR):** See ETS 300 785 [12].

**SDH Management Network (SMN):** This is a subset of the TMN (see ITU-T Recommendation G.784 [13]).

**SDH management sub-network (SMS):** This is a subset of the SMN (see ITU-T Recommendation G.784 [13]).

**SDH physical interface (SPI):** The SPI function converts an internal logic level STM-n signal into an STM-n line interface signal (see ITU-T Recommendation G.783 [10]).

**Section Overhead (SOH):** SOH information is added to the information payload to create an STM-n. It includes block framing information and information for maintenance, performance monitoring and other operational functions.

**sub-STM-1:** The medium capacity SDH format for transport at RRRP of an AU-3 equivalent capacity at 51,840 Mbit/s (see ITU-R Recommendation F.750 [1] and ITU-T Recommendation G.707 [4]).

**sub-STM-1:** The concept of a low capacity SDH format for transport of lower order VC equivalent capacity.

**Synchronous Equipment Management Function (SEMF):** The SEMF converts performance data and implementation specific hardware alarms into object-oriented messages for transmission over DCCs and/or a Q interface (see ITU-T Recommendations G.782 [9] and G.783 [10]).

**Synchronous Equipment Timing Physical Interface (SETPI):** The SETPI function provides the interface between an external synchronization signal and the multiplex timing source (see ITU-T Recommendation G.783 [10] and the ITU-T Recommendation G.81x series [17]).

**Synchronous Equipment Timing Source (SETS):** The SETS function provides timing reference to the relevant component parts of multiplexing equipment and represents the SDH network element clock (see ITU-T Recommendation G.783 [10]).

**Synchronous Transport Module (STM):** A STM is the information structure used to support section layer connections in SDH. See ITU-T Recommendation G.707 [4].

**Synchronous Transport Module for sub-STM-1 Radio-Relay (STM-RR):** See ITU-R Recommendation F.750 [1].



**Telecommunications Management Network (TMN):** The purpose of a TMN is to support administrations in management of their telecommunications network (see ITU-T Recommendation M.3010 [18]).

**Tributary Unit (TU):** A TU is an information structure which provides adaptation between the lower order path layer and higher order path layer (see ITU-T Recommendation G.707 [4]).

**Tributary Unit Group (TUG):** One or more TUs, occupying fixed, defined positions in a higher order VC payload is termed as a tributary unit group.

**T, T':** Access points of telecommunications equipment as defined in ITU-R Recommendation F.596 [19].

**Type IV multiplexer:** This provides the translation functions to allow C-3 payloads in a VC-3 to transit a network that uses SDH equipment which cannot support AU-3.

**Virtual Container (VC):** A VC is the information structure used to support path layer connections in the SDH. See ITU-T Recommendation G.707 [4].

## 3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ADM	Add and Drop Multiplexer
ATM	Asynchronous Transfer Mode
AU	Administrative Unit
AUG	Administrative Unit Group
BB	BaseBand
BER	Bit Error Ratio
BIP	Bit Interleaved Parity
C	Container
DCC	Data Communication Channel
DRRS	Digital Radio-Relay System
ECC	Embedded Communication Channel
FAW	Frame Alignment Word
FEC	Forward Error Correction
HDSL	High Digital Subscriber Line
HOVC	Higher Order Virtual Container
HPA	Higher order Path Adaptation
HPC	Higher order Path Connection
HPT	Higher order Path Termination
IOS	Intra-Office Section
IOST	Intra-Office Section Termination
ISI	Intra-System Interface
ITU-R	International Telecommunication Union-Radiocommunication sector
ITU-T	International Telecommunication Union-Standardization sector
LOVC	Lower Order Virtual Container
LPA	Lower order Path Adaptation
LPC	Lower order Path Connection
LPT	Lower order Path Termination
MCF	Message Communications Function
MS	Multiplex Section
MSA	Multiplex Section Adaptation
MSA-RR	Multiplex Section Adaptation for sub-STM-1 SDH Radio-Relay
MSOH	Multiplex Section OverHead
MSP	Multiplex Section Protection
MST	Multiplex Section Termination
MST-RR	Multiplex Section Termination for sub-STM-1 Radio-Relay
MUX	MUltipleXer
NE	Network Element
NNI	Network Node Interface
OH	OverHead
OHA	OverHead Access

PDH	Plesiochronous Digital Hierarchy
POH	Path OverHead
QAM	Quadrature-Amplitude Modulation
RCSOH	Radio Complementary Section OverHead
RF	Radio Frequency
RFCOH	Radio Frame Complementary OverHead
ROHA	Radio OverHead Access
RPI	Radio Physical Interface (generic)
RPPI	Radio Plesiochronous Physical Interface
RPS	Radio Protection Switching
RRRP	Radio-Relay Reference Point for sub-STM-1 radio-relay
RS	Regenerator Section
RSOH	Regenerator Section OverHead
RSPI	Radio Synchronous Physical Interface
RsSPI	Radio sub-STM-1 Synchronous Physical Interface
RST	Regenerator Section Termination
RST-RR	Regenerator Section Termination for sub-STM-1 Radio-Relay
SDH	Synchronous Digital Hierarchy
SEMF	Synchronous Equipment Management Function
SETPI	Synchronous Equipment Timing Physical Interface
SETS	Synchronous Equipment Timing Source
SG	Study Group
SMN	Synchronous Management Network
SMS	SDH Management Sub-network
SOH	Section OverHead
SPI	SDH Physical Interface
STM	Synchronous Transport Module
STM-N	Synchronous Transport Module of order N
STM-RR	Synchronous Transport Module for sub-STM-1 Radio-Relay
TMN	Telecommunications Management Network
T, T'	Baseband access points
TU	Tributary Unit
TUG	Tributary Unit Group
VC	Virtual Container

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## 4 Aspects of SDH regarding DRRS

Agreement was reached to approve a new activity plan and to study the following important items:

- a) the possible need for an additional synchronous interface rate for the SDH below the STM-1 level;
- b) possible transport of virtual containers, e.g. VC 3, and additional OH bytes if any;
- c) functional block diagram;
- d) network structure and network elements; types of system application;
- e) baseband interfaces standardized by ITU-T: physical characteristics and functionality of the BB interface requirements;
- f) implications of synchronization in an SDH network on radio-relay system design (e.g. reference clocks, jitter, wander, ...);
- g) performance aspects;
- h) impact of SDH specific multiplex structures (ITU-T Recommendations G.781 [20], G.782 [9], G.783 [10], G.784 [13]) on radio-relay systems;
- i) transmission network management control and supervision requirements for radio relay system;

- j) identification of bytes and their function in the SOH which should be allocated for:
  - media specific usage;
  - way side traffic;
- k) identifications of any signals produced by the radio system which would complement and aid the SOH functions e.g. error performance monitoring;
- l) protection switching arrangements which are appropriate for radio-relay systems in an SDH network;
- m) requirements of operation and maintenance; radio specific parameters to be monitored;
- n) identification of specific transmission characteristics;
- o) migration strategy to an SDH network;
- p) utilization of the Multiplex Section Overhead (MSOH) and the Regenerator Section Overhead (RSOH) by radio-relay systems at radio terminals and repeaters.

In view of the urgency it was agreed to give highest priority to the solution of items a), j), k), l), m) and p).

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## 5 TM4 position

Answers to the following items have been agreed:

### 5.1 Item a)

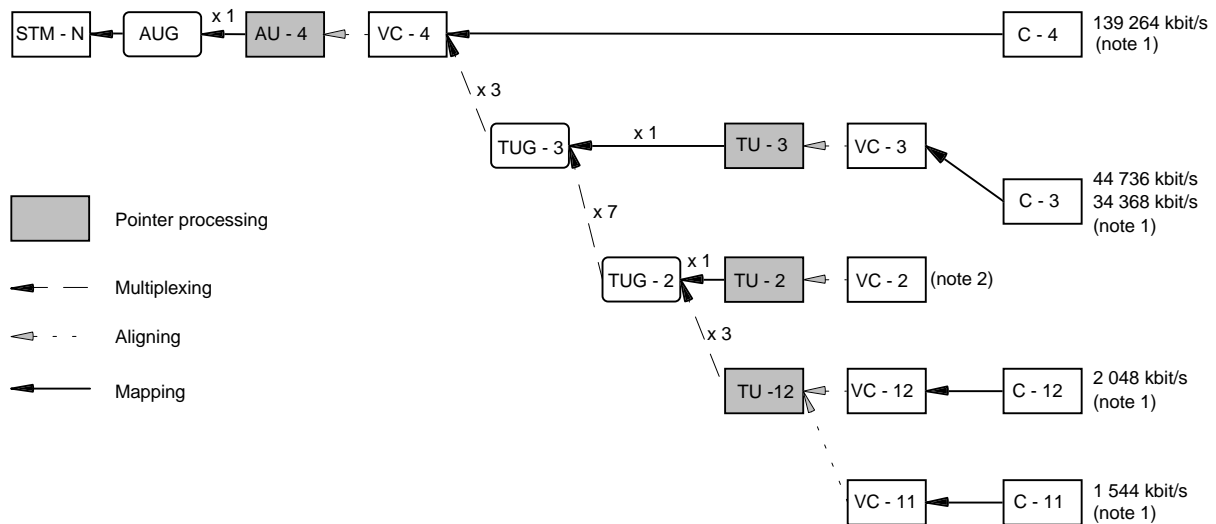
TM4 considered the draft new opinion of ITU-R SG 9 on the "Requirements of an additional interface rate to the synchronous digital Hierarchy" below the STM-1 level (see document 9/441 Corrigendum 2 which became Opinion 89). There is no need for an additional synchronous interface with a bit rate below STM-1 level.

### 5.2 Item b)

ITU-T have specified that the lowest level interface to the synchronous digital hierarchy shall be 155,52 Mbit/s and this has been recently confirmed by TM3. There is a need in parts of a telecommunications network to transport a partially filled payload comprising low and medium capacity signals. Where fibre systems are employed, this does not represent a problem (apart from economic considerations). In the case of radio systems, spectrum utilization is an important issue and needs to be taken into account. Obviously, the deployment of STM-1 radio systems in such circumstances would be inappropriate.

Since the ITU-T does not define an interface rate below STM-1, the option to transmit selected virtual containers together with the Section Overhead has been considered, and such an arrangement has been called sub-STM-1. Information concerning signal interfaces and multiplexing for sub-STM-1 is given in ITU-R Recommendations F.750 [1] and F.751 [2] and in the present document.

The SDH multiplexing route as adopted by ETSI is shown in figure 1.



NOTE 1: ITU-T Recommendation G.702 [14] tributaries associated with containers C - x are shown. Other signals, e.g. ATM, can also be accommodated.

NOTE 2: Virtual concatenation of VC - 2 could be used for the transport of new services at non-hierarchical bit rates.

**Figure 1: ETS 300 147 [21] multiplexing structure**

When the STM-1 signal is partly filled, there is the opportunity for radio-relay to transport only part of the STM-1 signal with the necessary SOH entities. This provides benefit in terms of radio spectrum saving and/or modulation complexity reduction.

Radio-relay systems at bit rate below STM-1 to be integrated in a SDH network have to guarantee the complete transparency of SDH functionality among two STM-1 standard interfaces.

In principle radio-relay systems at bit rates suited for the transport of each virtual container (VC-12, VC-2, VC-3) could be conceived.

The following example addresses radio-relay systems at a bit rate below STM-1 necessary to transport VC-3 or equivalent capacity (see figure 2).

The interconnection between an SDH network and a Synchronous radio-relay system based on the STM-RR module can be represented as shown in figure 2. The interconnection requires to de-multiplex the aggregate signal either to the TU-3 or to 7×TUG-2 depending on the containers transported in the payload.

The SDH multiplexing route to form the Synchronous Transport Module for Radio Relay (STM-RR) is deduced from the SDH multiplexing route as indicated in figure 3 to maintain the benefit and the flexibility of the synchronous multiplexing the mapping of VC-3 into the STM-RR may be performed using the pointer contained in the AU-3.

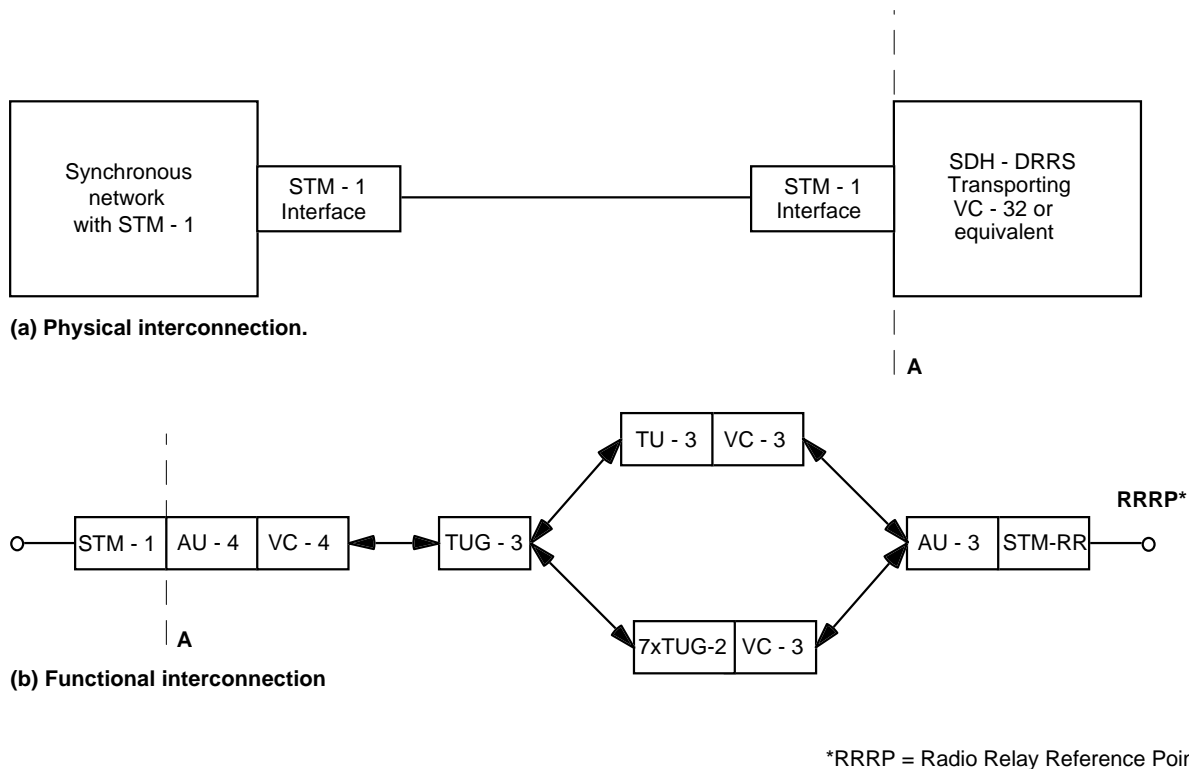
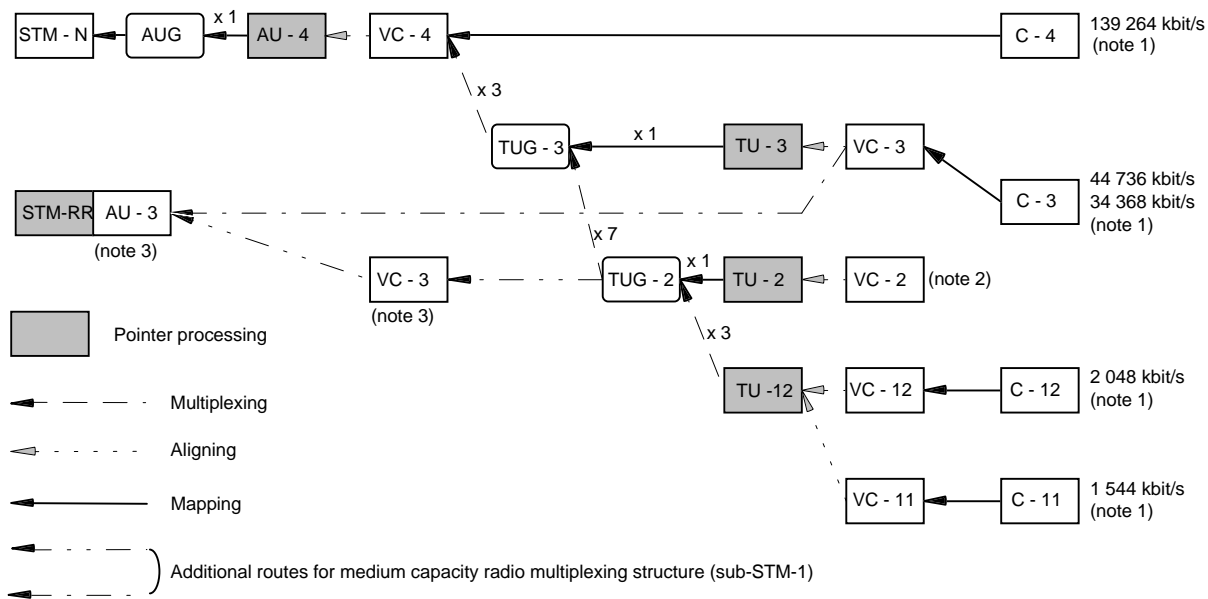


Figure 2: Example of interconnection between SDH network and a medium capacity SDH radio relay



NOTE 1: ITU-T Recommendation G.702 [14] tributaries associated with containers C - x are shown. Other signals, e.g. ATM, can also be accommodated.

NOTE 2: Virtual concatenation of VC - 2 could be used for the transport of new services at non-hierarchical bit rates.

NOTE 3: This VC 3/AU 3 mapping is in accordance with the ITU-T Recommendation G.707 [4] structure, but it cannot be utilized to map an AUG structure to form an STM-1 signal.

Figure 3: Multiplexing structure for medium capacity radio (sub-STM-1)

## 5.2.1 Liaison with TM3 on sub-STM-1

At its meeting in Bristol, 12-16 October 1992, TM3 examined the request from TM4 to include in the SDH multiplexing structure the sub-STM-1 DRRS which has been agreed within TM4 for radio-relay systems.

TM3 decided not to include the sub-STM-1 DRRS in the ETS 300 147 [21] on SDH multiplexing structure taking the following into account:

The additional route for medium capacity radio-relay systems does not add any multiplexing structure but is just concerned with the transport of a VC-3 over radio-relay systems.

The relevant ETS 300 147 [21] explicitly excludes the multiplexing via the AU-3.

It is understood that the Network Node interface (NNI) between sub-STM-1 DRRS and other SDH transmission systems or SDH network elements will be an STM-1 interface with a AU-4/TUG-3 structured frame which is partially filled (only one VC-3 used).

The necessary conversion between the NNI and the Radio Relay Reference Point (RRRP) based on the AU-3 structured frame is not relevant for ETS 300 147 [21] but should be described in the equipment specification for sub-STM-1 DRRS. The conversion function is illustrated in figure 3.7 of ITU-T Recommendation G.782 [9] for type IV Multiplexers.

The transport of 7×TUG-2 is performed by multiplexing them into VC-3 and then mapping into an AU-3 according to ITU-T Recommendation G.707 [4] to form the STM-RR.

At the 1993 meeting in Munich, TM4 discussed two alternative solutions for the multiplexing of payload from the NNI into the RRRP:

- the first solution is that the sub-STM-1 radio terminal has the ability to perform complete multiplexing comparable to an Add and Drop Multiplexer (ADM). This is necessary if the payload is distributed over the entire STM-1 frame and access to any VC-2 or VC-1 should be provided;
- the second solution is that the payload at the NNI is already packed in only one of the TUG-3s. The radio terminal will in this case perform a simpler multiplexing.

These solutions were suggested to TM3 in a liaison from the Munich meeting, and TM3's response was that both these approaches are valid and may be used.

A radio-relay link which may or may not include radio repeaters made up with STM-RR systems has to be considered as an SDH multiplex section.

The requirement for transparency of VC-4 POH through STM-RR is under study.

Figure 4 shows the content of the STM-RR Overhead; specific SOH bytes have not been assigned. However, depending on the sub-STM-1 radio relay applications, some of the SOH bytes may be available because their standard function as in ITU-T Recommendation G.707 [4] may not be necessary or may be achieved by other means, e.g. use of FEC indications for radio performance monitoring. Depending on the implementations, bytes C1, F1 and/or one of the data communication channels may be used. When C1 and/or F1 are used as media specific bytes they will be renamed within TM4 as C1R and F1R as shown in figure 4.

TM3 has been addressed (see document TM4(94)/08 annex 3) in order to evaluate the above usage of C1 and F1.

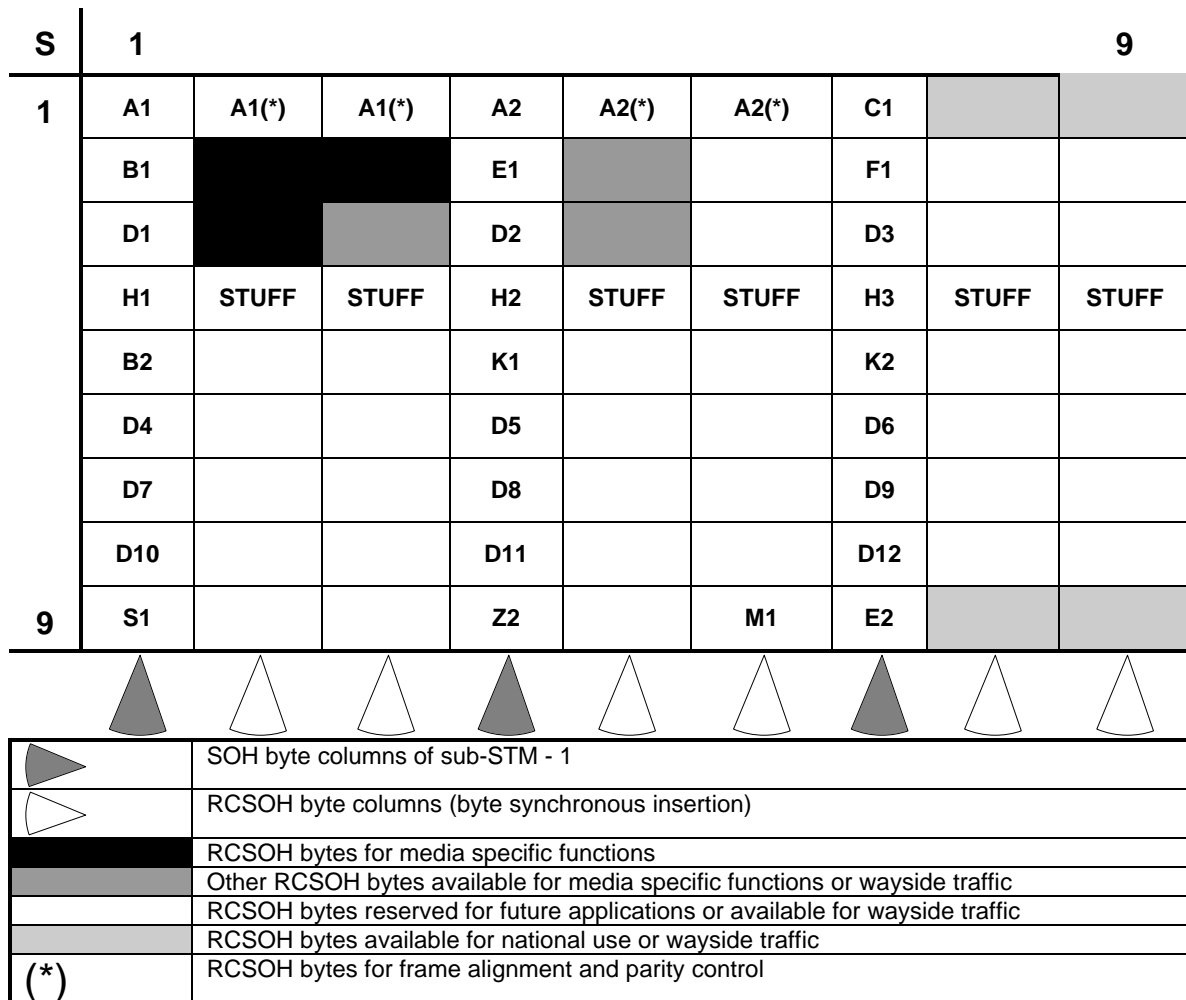
Unless TM3 will state its disagreement TM4 will use this approach.

STM - RR OH			
RSOH	A1	A2	C1(C1R)
	B1	E1	F1(F1R)
	D1	D2	D3
POINTER	H1	H2	H3
MSOH	B2	K1	K2
	D4	D5	D6
	D7	D8	D9
	D10	D11	D12
	S1	Z2	E2

**Figure 4: Radio Relay Section Overhead (SOH - RR)**

As an alternative, bytes of an additional proprietary Radio Frame Complementary Overhead (RFCOH) or a full STM-1-like SOH format, in which 6 columns may be regarded as a byte synchronous Radio Complementary Section Overhead (RCSOH), may be used.

For the latter solution figure 5 shows an example of possible usage of the bytes.



**Figure 5: Mixed SOH and RCSOH for sub-STM-1 (full STM-1 compatibility)**

## 5.2.2 Network adaptation to SDH VC-2.5c

In order to maximize the payload capability of sub-STM-1 systems, there exists the facility for virtual concatenation of containers. Mappings are defined for 34 Mbit/s streams using VC-2.5c mappings. VC-2.5c concatenation is the use of five VC-2 virtual containers to form a single virtual container. The mappings for 34 Mbit/s into VC-2.5c is described in subclause 11.4 of ETS 300 174 [22].

## 5.2.3 Sub-STM-1 systems

Further studies on sub-STM-1 systems have been carried out based on the connection of customers via add/drop multiplexers to SDH rings. Applications have been identified at an even lower transmission rate for three technologies, namely radio, fibre optic and copper pair cables. While the latter are outside the remit of TM4, it is interesting to note that there are technical and economic motivations for sub-STM-1 ( $\leq 51,84$  Mbit/s) systems for all transmission media.

The ITU-T is unlikely to define an interface to the SDH below 155,52 Mbit/s, although there are advantages in extending the SDH network to the customer as indicated in figure B6. This extension can be achieved and still maintain radio spectrum efficiency by the transmission of lower order paths e.g. VC-12, VC-2 to deliver the PDH signal to the customer. It is proposed that TM4 considers extending the low capacity transmission rates to include sub-STM-1 where VC-12 = 2,3 Mbit/s and VC-2 = 6,9 Mbit/s.

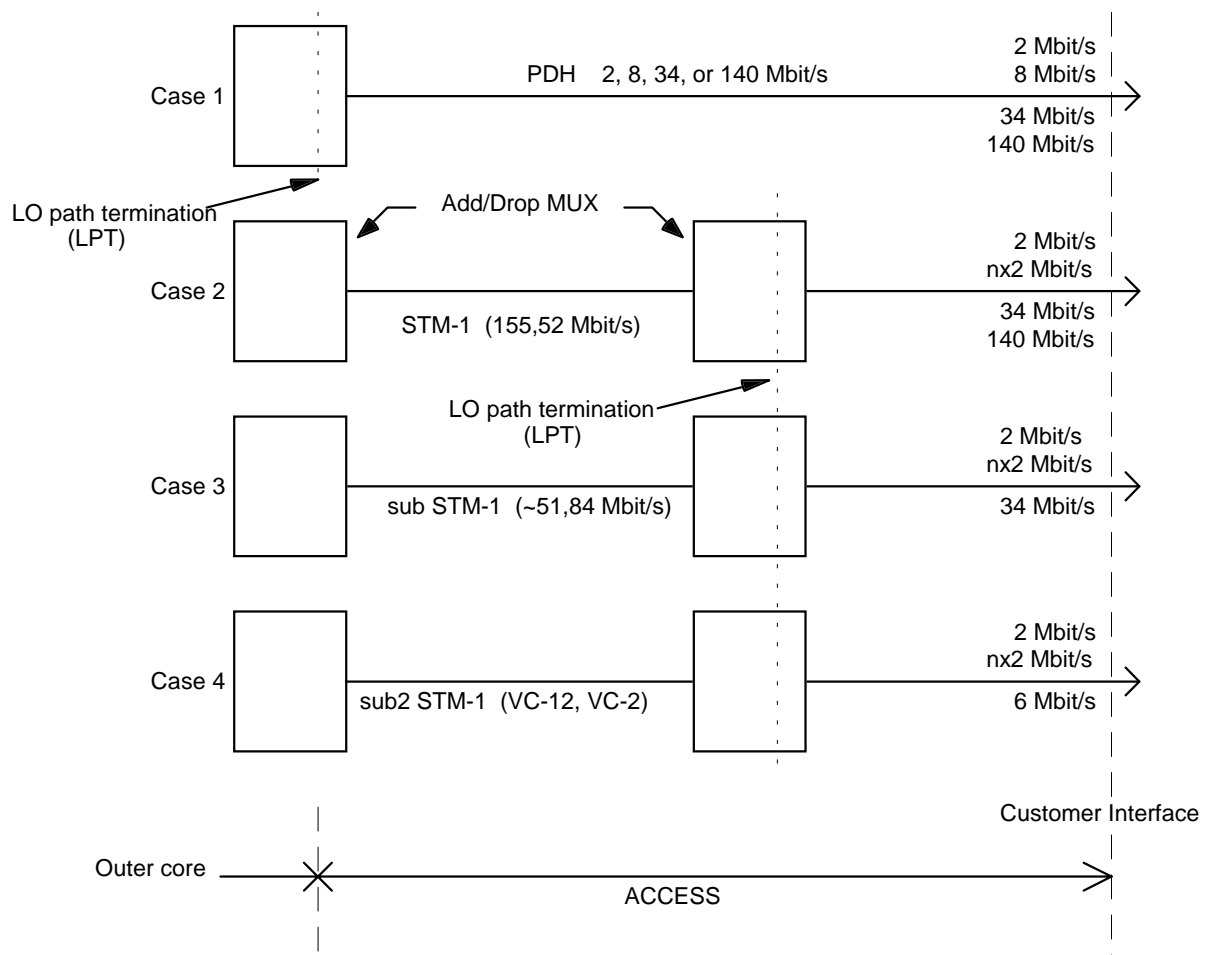


Figure 6: Possible delivery methods



## 5.2.4 Liaison with TM3 on sub-STM-1

A contribution on this subject was submitted to the ETSI TM3 meeting (12-16 October 1992). TM3 Working Group 5, Functional Aspects, considered the following documents concerning sub-STM-1:

- TD 46 on "The requirement for sub-STM-1 Section Layers";
- TD 47 on "A TU-12 Section Layer Frame Structure".

It was explained that although a sub-STM-1 transport rate of 51,84 Mbit/s had been defined for the purposes of radio spectrum efficiency, there was a need to consider even lower rates to carry VC-1 and VC-2 payloads. Benefits in this requirement can be foreseen for passive optical networks and High bit rate Digital Subscriber Line (HDSL) on copper as well as for radio and satellites.

There are many aspects that need to be studied, and it was proposed that a draft technical report is prepared and submitted to the next TM3 meeting for approval. The terms of reference of this study cover the transmission of VC-1 and VC-2 signals and does not extend to the definition of a new user defined interface. The customer interface is at the primary rate (1,5 and 2 Mbit/s) of the PDH.

There are several technical issues that need study. For instance, it is appropriate to convert a VC-12 into a VC-frame by the addition of a Frame Alignment Word (FAW).

This FAW could be multiplexed with a data communication channel for future possible remote network management. Another aspect that requires investigation is timing and relates to a possible requirement to deliver timing information to the customer's premise for future use.

The TM3 report on sub-STM-1 systems will be of interest to TM4 and will assist TM4 members to formulate the technical requirements for sub-STM-1 radio-relay systems.

## 5.3 Item c)

### 5.3.1 Review of present ITU-T and ITU-R Recommendations

ITU-T Recommendations G.782 [9] and G.783 [10] recommendation gives information about general aspects of multiplexing scheme and characteristics of SDH equipment functional blocks respectively. Moreover ITU-T Recommendation G.958 [11] gives specific characteristics for optical interfaces of Line Systems. ITU-R Recommendation F.750 [1] gives information about the architecture and functional aspects of DRRS for SDH based networks.

### 5.3.2 Comments on ITU-R Recommendation F.750 (1994) in comparison with ITU-T G.78x Recommendations

ITU-R Recommendation F.750 [1] was finalized at the ITU-R Kobe meeting in 1991, thus the material included in it is outdated when considered from the point of view of current TMN and SDH standards which have grown significantly since 1991. The functional blocks reported in figures 7 and 8 of ITU-R Recommendation F.750 [1] are not consistent with the formal functional block diagrams given in figures 2.1 of both ITU-T Recommendations G.783 [10] and G.782 [9].

Apart from the formal appearance of figures 7 and 8 the most inconsistent items are as follows:

#### 5.3.2.1 Differences between RPI and SPI

ITU-R Recommendation F.750 [1] states that "It is not practicable for radio systems to provide a radio-frequency interface for mid-air interconnectivity.(.....) Therefore, standardization of a mid-air interface is not required".

From this statement it follows that: a new reference point "R" representing the physical transmission medium interface has to be defined.

In subclause 7.2 it is stated that the maintenance functions for Radio specific alarms will be available at "S1" reference point. This is not consistent because S1 is a fully defined reference point for SPI functional block. It is then necessary to define a new specific Sx reference point, with all the information related to the RPI functional block.

### 5.3.2.2 Further comments on RPI naming

ITU-R Recommendation F.750 [1], naming the radio physical interface simply RPI, implicitly makes no distinction between the synchronous and the plesiochronous radio physical interfaces. However, since it just refers to SDH DRRS this might mean that it is simply misspelled. The correct terminology to be used should be RSPI for the synchronous (STM-N version) functional block, leaving open the possibility for the Radio Plesiochronous Physical Interface (RPPI).

TM1, TM2 and TM4 will go along with the split terminology RSPI, RPPI.

### 5.3.2.3 RF branching functional block

In ITU-R Recommendation F.750 [1] figures 7 and 8 an RF branching functional block is depicted between the RPI block and the antenna (e.g. physical medium). This fact is not consistent because RF branching cannot be considered a functional block. It is better to remove this block because no additional functionality could be identified for it.

### 5.3.2.4 RPI functional block management

In ITU-R Recommendation F.750 [1] subclause 7.2 there is a list of "Maintenance Functions" for radio equipment. This list seems, again, to be confused and inadequate. As an example the "transmitter status" is used to indicate both the "transmitter power level out of range" and "transmitter major hardware failure".

## 5.3.3 TM4 position

The generalized functional block diagram can be found in ETS 300 635 [16] and ETS 300 785 [12].

## 5.4 Item d)

For further study.

## 5.5 Item e)

The physical characteristics of the interfaces have to be defined for the SPI function.

SDH radio-relay systems will use electrical or optical interfaces. Electrical interfaces are defined in ITU-T Recommendation G.703 [15].

If optical interfaces are used in DRRS the infra office interface I-1 mentioned in table 1 of ITU-T Recommendation G.957 [23] is proposed.

The use of other optical interfaces is under study.

## 5.6 Item f)

See ITU-R Recommendation F.750 [1].

TM3 is studying the definition of a synchronizing byte possibly in the MSOH for STM-N ring structures.

Taking into account that in radio-relay systems transporting only the relevant part of partially filled STM-1 signals, in rows 5 to 9 of the SOH (see figure 4) no byte is available apart from the Zi bytes, TM3 is asked to allocate this function within one of these Zi bytes.

## 5.7 Item g)

### SDH network delay

A liaison has been received from TM3 dealing with the issue of additional delay in the transmission network as a consequence of introducing new technology. A study of this subject is particularly important if network operators are to avoid the introduction of echo canceller on circuits over parts of the network not previously affected.

Factors to be examined include:

- a) increasing use of optical fibre instead of coaxial cable and radio-relay transmission;
- b) protection switching incorporating media and route diversity;
- c) new transmission and multiplexing technologies introducing coding and data processing delays;
- d) apportionment of end-to-end delay values between transmission, multiplexing and switching.

It is felt that terrestrial point-to-point radio-relay is not a major contributor to network delay and TM4 will await the outcome of TM3 studies before taking action.

## 5.8 Item h)

The scrambler given in ITU-T Recommendation G.707 [4] is not sufficient for DRRS with multi-state modulation (> 64 QAM), a scrambler with a larger sequence is necessary.

When defining SDH radio-relay systems similar functional blocks as described in ITU-T Recommendations G.782 [9] and G.783 [10] should be used (see section 4.1.2 of ITU-R Recommendation F.751 [2]).

As described in UK-document 2/24 to TM3 WP2 meeting and document TM4(91)/26 the pointer adjustment mechanism as specified in ITU-T Recommendation G.707 [4] appears not to be sufficiently protected against errored bit events not having a Poisson distribution statistics.

## 5.9 Item i)

SDH-DRR has to be considered as subset of the Telecommunication Management Network (TMN) described in ITU-T Recommendation M.3010 [18].






























ITU-R Recommendation F.750 [1] gives:

- details of how to manage SDH-DRRS within a SDH Management Sub-network (SMS);
- details of an SMS composed by mixed multiplex and Radio Systems, with possible TMN interfaces;
- a minimum set of primitives for radio specific alarms available at S1 radio equivalent (S50) reference point (refer to figure 2.2 of ITU-T Recommendation G.783 [10] and ETS 300 635 [16]).

## 5.10 Item j)


TM4 note the STM-1 section overhead in figure 5.2 of ITU-T Recommendation G.707 [4] due to the decision of ITU-T SG XVIII to reserve bytes S(2.2.1), S(2.3.1), S(2.5.1), S(3.2.1), S(3.3.1) and S(3.5.1) for media specific usage.


It is the view of TM4 that, at present, 3 bytes are needed for radio-relay systems, and they are allocated in position S(2.2.1), S(2.3.1) and S(3.2.1) as shown in figure 7.

S	1							9		
1	A1	A1	A1	A2	A2	A2	C1			
	B1			E1			F1			
	D1			D2			D3			
	<b>AU Pointers</b>									
	B2	B2	B2	K1			K2			
	D4			D5			D6			
	D7			D8			D9			
	D10			D11			D12			
9	S1	Z1	Z1	Z2	Z2	M1	E2			

 Bytes reserved for media specific usage

 Bytes reserved for national use

 Bytes reserved for future international standardization

 Bytes also reserved by ITU-T for media specific usage but at present not used for this purpose by radio-relay systems

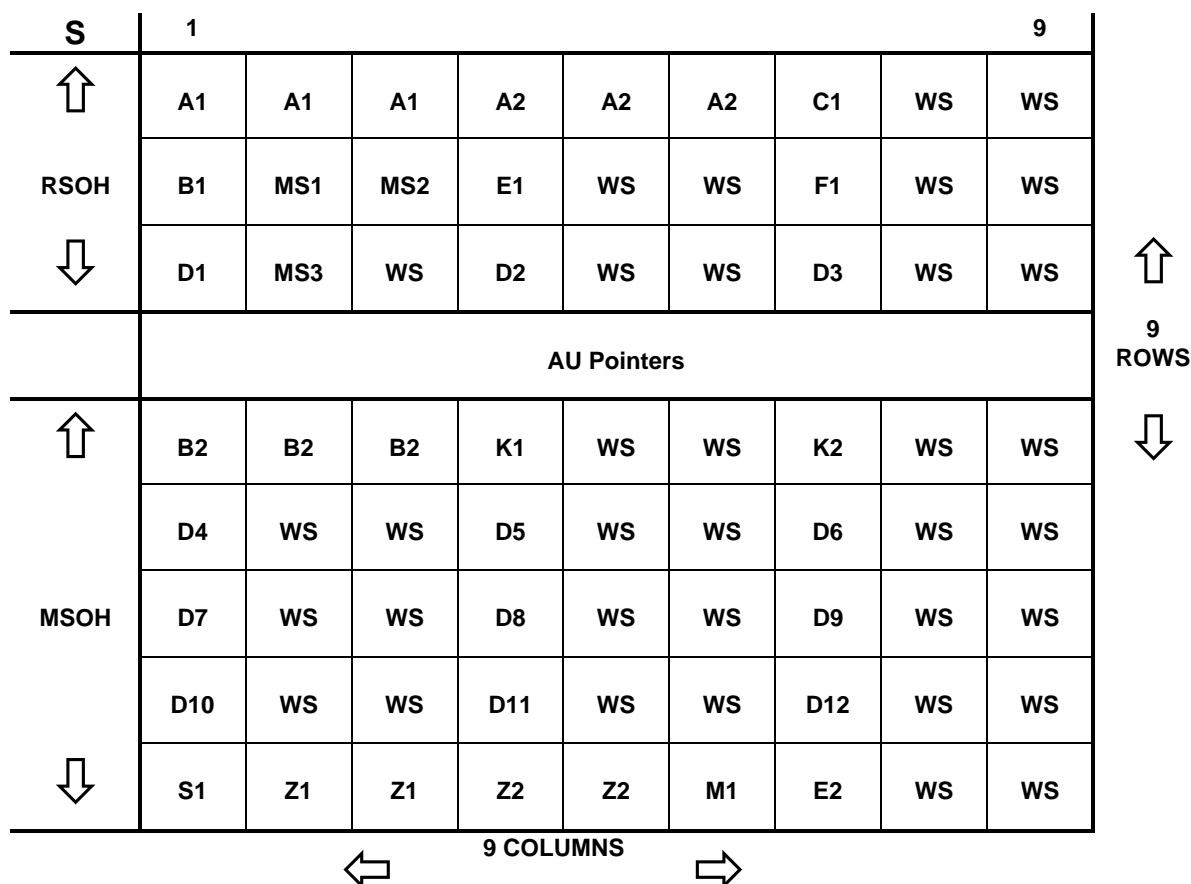
**Figure 7: STM-1 SOH bytes**

However, all the 26 unallocated bytes, plus the 3 media specific bytes not used for medium specific purposes and, with the agreement of the administration concerned, plus the 6 bytes reserved for national use can provisionally be utilized for the transmission of wayside traffic with capacities up to 2,048 Mbit/s.

For example figure 8 shows the possible usage of SOH bytes for 2,048 Mbit/s way-side traffic.

Way-side traffic can also be accommodated outside SDH structure within specific radio frame complementary overhead.

Only for sub-STM-1 bytes C1 and F1 as shown in figure 4 could be used for media specific purpose.



MSx = Media specific bytes  
 WS = Bytes for wayside traffic

Figure 8: Example of usage of SOH for plesiochronous transmission of 2,048 Mbit/s wayside traffic

## 5.11 Item k)

Any error correction capability produced by a radio system can be intrinsically utilized for efficient (FAST BER) error monitoring to exploit "early warning" switching in twin path or multi-line protection system or for other information useful for monitoring purposes.

## 5.12 Item l)

The protection switching function (MSP) foreseen in ITU-T Recommendation G.783 [10] is not suitable, if e.g. an improvement of the transmission quality against multipath activity in a radio link is required.

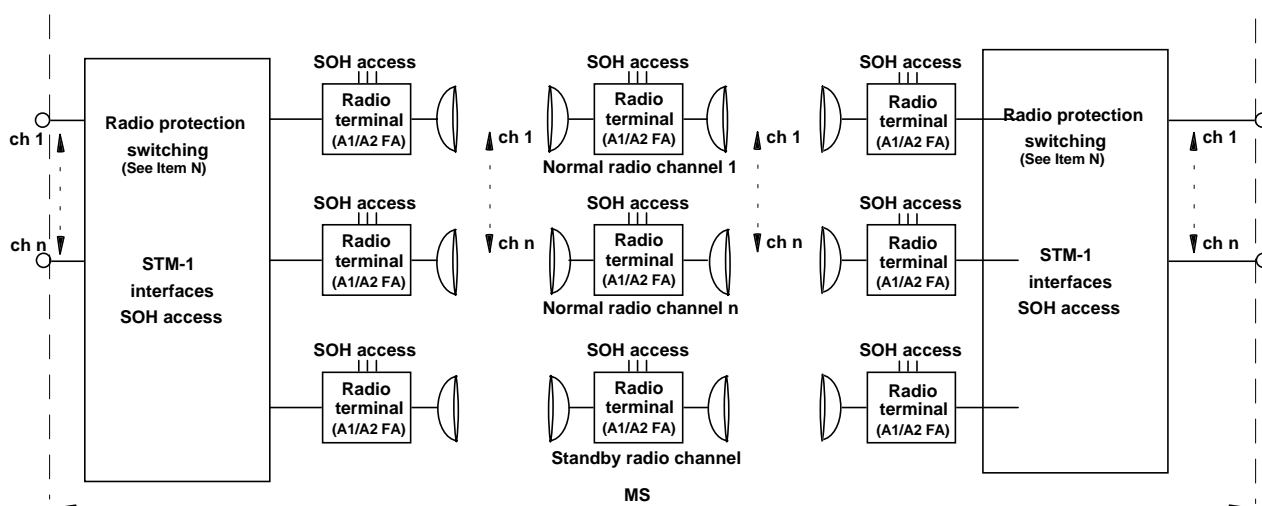
As a consequence, in these cases, a radio link should have its own twin path or multi-line hitless protection switching system.

### 5.12.1 1 + 1 protection

1 + 1 protection switching section can be either a regenerator section or a multiplex section.

### 5.12.2 n + m protection

A functional block diagram for an n + 1 configuration is shown in figure 9.



**Figure 9: n + 1 Switching arrangement**

Multiplex Section Adaptation (MSA) functions and therefore pointer activities are located only at the terminals.

As suggested in ETS 300 635 [16] different solutions are possible so that the exact position of RPS function should not be a subject of standardization.

Because K1 and K2 bytes are used for network protection, a data communication channel for the switching control signals should be established in a media specific byte as mentioned in item j).

From figure 9 it can be seen that SDH DRRS are frame aligned (A1/A2 FA), on each hop, by means of A1 and A2 frame words of the STM-1 SOH.

During multipath phenomena the different operating channels may require the stand-by channel on the basis of BER alarms.

When a switch operation starts the signal is transmitted in parallel on the operating channels and on the stand-by channel. Since the various STM-1 signals of the operating channels and of the stand-by channel may not be synchronized in frequency (if the network is still not completely synchronized) and in phase, during the switching operation, the alignment may be lost on each hop of the stand-by channel. This event increases the switching operation time, which, on the other hand, should be as fast as possible (typically less than 10 ms) in order to counteract multipath dynamics and improve the system quality.

This implies the necessity of synchronization of all STM-1 signals both in frequency and in phase obtained by a section adaptation (MSA) function on the STM-1 signals in the radio terminal station (radio equipment and switching system).

Since a MSA terminates and starts a multiplex section, the consequence is that a n + m multi-line hitless switching section should be a multiplex section.

Anyway no termination of the MS may be possible if the number of regenerator sections between radio terminals with RPS is limited so that, the total time of detect/restore the A1/A2 frame loss/alignment of the repeater chain will not affect the total switching time over the required minimum to ensure efficient hitless protection.

See ETS 300 635 [16].

### 5.13 Item m)

See ETS 300 635 [16] and ETS 300 785 [12].

### 5.14 Item n)

For further study.

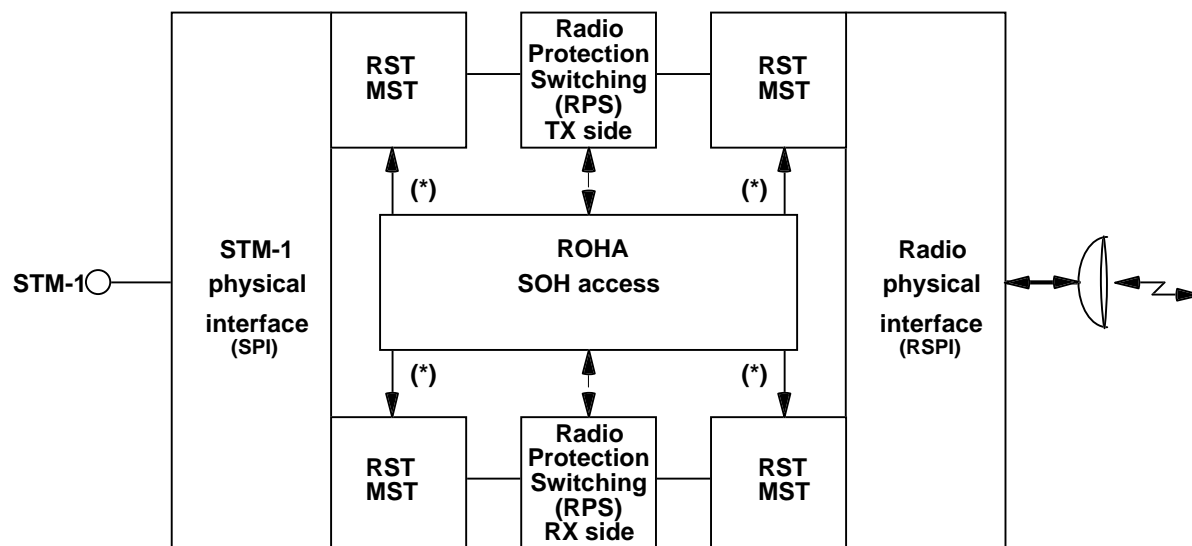
## 5.15 Item o)

See appendix 2 of ITU-R Recommendation F.750 [1].

## 5.16 Item p)

To utilize the section overhead, the bytes mentioned in item j) could be accessed either inside or outside the protection switching.

In figures 10 and 11 the access of the overhead is shown.

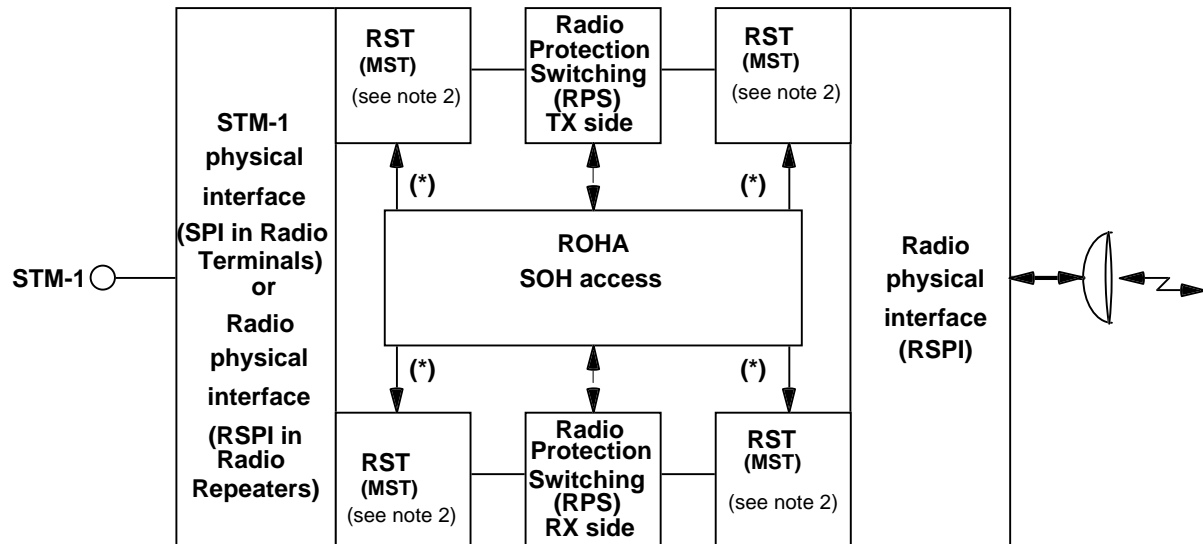


(\*) Monitored and processed bytes:

A1, A2, D1÷D3, D4÷D12  
 E1, E2, NU, B1, B2  
 C1 (see note)  
 F1 (see note)

NOTE: Confirmation is required that these bytes are available for system use.

**Figure 10: Radio system MST (including RST) functions**



(\*) Monitored and processed bytes:

A1, A2, D1÷D3, D4÷D120

E1, E2, NU, B1, B2, C1

F1 (see note 1), NU rows 1÷3 and 5÷9, B1, C1 (see note 1)

NOTE 1: Confirmation is required that these bytes are available for radio system use.

NOTE 2: If rows 5÷9 are accessed, even parity of B2 byte should be maintained.

**Figure 11: Radio system RST functions**



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# History

<b>Document history</b>		
Edition 1	July 1995	Publication as TM-TR 004
V1.1.2	June 1997	Publication