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Foreword

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

ETRs are informative documents resulting from ETSI studies which are not appropriate for European Telecommunication Standard (ETS) or Interim European Telecommunication Standard (I-ETS) status. An ETR may be used to publish material which is either of an informative nature, relating to the use or the application of ETSs or I-ETSs, or which is immature and not yet suitable for formal adoption as an ETS or an I-ETS.

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1 Scope

This ETSI Technical Report has been produced in response to mandate BC-T-324 [1] issued to ETSI by the European Commission Directorate General III (EC DG III). The object of this mandate is to produce European Telecommunication Standards for access to Synchronous Digital Hierarchy (SDH) leased lines with Synchronous Transport Module-N (STM-N) network presentations at the Network Termination Point (NTP). The two parts of the mandate are, firstly, an investigation of the technical feasibility and the requirements, and secondly, depending on the agreement of the EC, the production of the relevant ETS. This ETR addresses the first part of the mandate.

The ETR is written in the Open Network Provision (ONP) context defined in the ONP framework Directive 90/387/EEC [2] and the leased line Directive 92/44/EEC [3]. It considers leased lines as a suitable basis to form part of a community-wide offer. It is intended that an ETS produced as a result of the second part of the mandate will be published in the indicative, non-mandatory section of the ONP List of Standards in the Official Journal of the European Community. Two previous reports on the standardisation of other leased lines have already been produced in this context: ETR 038 [4] and ETR 087 [5].

The ETR examines the technical aspects of the standardisation of SDH leased lines and details the work needed to produce the ETS. It covers the various technical options taking into account the current situation of SDH networks and their expected evolution.

2 References

This ETR incorporates by dated and undated reference, provisions from other publications. These references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETR only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] EC DG III: "Standardisation mandate BC-T-324 on access to SDH Leased digital Bandwidth with Standardized STM-N (N X 155 Mbit/s) Network Presentation at the NTPs".

[2] EC Directive 90/387/EEC: "Council Directive on the establishment of the internal market for telecommunications services through implementation of Open Network Provision".

[3] EC Directive 92/44/EEC: "Council Directive on the application of Open Network Provision to leased lines".

[4] ETR 038: "Business Telecommunications (BT); Open Network Provision (ONP) technical requirements; Standardisation requirements for ONP leased lines".

[5] ETR 087: "Business Telecommunications (BT); Open Network Provision (ONP) technical requirements; Standardisation requirements for ONP leased lines; Higher order leased lines".

[6] ITU-T Recommendation G.823: "The control of jitter and wander with digital networks which are based on the 2048 kbit/s hierarchy".

[7] ITU-T Recommendation G.803: "Architecture of transport networks based on the synchronous digital hierarchy (SDH)".

[8] ETS 300 147: "Transmission and Multiplexing (TM); Synchronous Digital Hierarchy (SDH) multiplexing structure".

[9] ITU-T Recommendation G.707: "Synchronous digital hierarchy bit rates".

[10] ITU-T Recommendation G.708: "Network node interface for the synchronous digital hierarchy".

[11] ITU-T Recommendation G.709: "Synchronous multiplexing structure".

[12] ETR 239: "Transmission and Multiplexing (TM); Synchronous Digital Hierarchy (SDH); List of documents relevant to SDH transmission equipment".

[13] ETS 300 417-1-1: "Transmission and Multiplexing (TM); Generic functional requirements for Synchronous Digital Hierarchy (SDH) equipment; Part 1-1: Generic processes and performance".

[14] prETS 300 417-2-1: "Transmission and Multiplexing (TM); Generic functional requirements for Synchronous Digital Hierarchy (SDH) transmission equipment; Part 2-1: Physical section layer functions".

[15] prETS 300 417-3-1: "Transmission and Multiplexing (TM); Generic functional requirements for Synchronous Digital Hierarchy (SDH) equipment; Part 3-1: STM-N regenerator and multiplex section layer functions".

[16] prETS 300 417-4-1: "Transmission and Multiplexing (TM); Generic functional requirements for Synchronous Digital Hierarchy (SDH) equipment; Part 4-1: SDH Path Layer Functions".

[17] ITU-T Recommendation G.783: "Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks".

[18] prETS 300 462: "Transmission and Multiplexing (TM); Generic requirements for synchronization networks".

[19] ITU-T Recommendation G.825: "The control of jitter and wander within networks which are based on the synchronous digital hierarchy (SDH)".

[20] ITU-T Draft Recommendation G.81s: "Timing characteristics of SDH equipment slave clocks (SEC)".

[21] ETS 300 166: "Transmission and Multiplexing (TM); Physical and electrical characteristics of hierarchical digital interfaces for equipment using the 2 048 kbit/s - based plesiochronous or synchronous digital hierarchies".

[22] ITU-T Recommendation G.703: "Physical/electrical characteristics of hierarchical digital interfaces".

[23] ETS 300 232: "Transmission and Multiplexing (TM); Optical interfaces for equipments and systems relating to the Synchronous Digital Hierarchy [ITU-T Recommendation G.957 (1993) modified]".

[24] ITU-T Recommendation G.957: "Optical interfaces for equipments and systems relating to the synchronous digital hierarchy".

[25] IEC 169/13: Part 13: "R.F. coaxial connectors with inner diameter of outer conductor 5,6 mm (0,22 in) - Characteristics impedance 75 ohms (Type 1,5/5,6) - Characteristics impedance 50 ohms (Type 1,8/5,6) with similar mating dimension".

[26] ITU-T Recommendation G.826: "Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate".

[27] I-ETS 300 416: "Transmission and Multiplexing (TM); Availability performance of path elements of international digital paths".

[28] ETR 114: "Transmission and Multiplexing (TM); Functional architecture of Synchronous Digital Hierarchy (SDH) Transport networks".

[29] ITU-T Draft Recommendation M.2101: "Performance limits for bringing into service and maintenance of international SDH paths and multiplex sections".

[30] ETS 300 337: "Transmission and Multiplexing (TM); Generic frame structures for the transport of various signals (including Asynchronous Transfer Mode (ATM) cells and Synchronous Digital Hierarchy (SDH) elements) at the CCITT Recommendation G.702 hierarchical rates of 2 048 kbit/s, 34 368 kbit/s and 139 264 kbit/s".

3 Abbreviations and definitions

3.1 Abbreviations

For the purposes of this ETR, the following abbreviations apply:

APS	Automatic Protection Switch
ATM	Asynchronous Transfer Mode
AUG	Administrative Unit Group
BNC	Bayonet Nut Connector
BIP-n	Bit Interleaved Parity-n
B-ISDN	Broadband Integrated Services Digital Network
DQDB	Distributed Queued Dual Bus
EMC	Electromagnetic Compatibility
HO	Higher Order
ISDN	Integrated Services Digital Network
LO	Lower Order
MSOH	Multiplex Section Overhead
NE	Network Element
NT	Network Termination
NTP	Network Termination Point
ONP	Open Network Provision
PABX	Private Automatic Branch eXchange
POH	Path Overhead
PDH	Plesiochronous Digital Hierarchy
PRA-ISDN	Primary Rate Access ISDN
PRC	Primary Reference Clock
RDI	Remote Defect Indicator
REI	Remote Error Indicator
RFI	Remote Failure Indicator
RSOH	Regenerator Section Overhead
SDH	Synchronous Digital Hierarchy
STM-N	Synchronous Transport Module-N
TBR	Technical Basis for Regulation
TE	Terminal Equipment
TU-n	Tributary Unit-n
VC-n	Virtual Container-n

3.2 Definitions

For the purposes of this ETR, the following abbreviations apply:

connection: A transport entity which is capable of transferring information transparently between connection points. A connection defines the association between the connection points and the connection points delimit the connection.

unidirectional connection: A connection which is capable of transparently transferring information from input to output.

bidirectional connection: A connection consisting of an associated pair of unidirectional connections capable of simultaneously and transparently transferring information in opposite directions between their respective inputs and outputs.

leased lines: The telecommunications facilities provided by a public telecommunications network that provide defined transmission characteristics between network termination points and that do not include switching functions that the user can control, (e.g. on-demand switching).

Network Termination Point (NTP): All physical connections and their technical access specifications which form part of the public telecommunications network and are necessary for access to and efficient communication through that public network.

Terminal Equipment (TE): Equipment intended to be connected to the public telecommunications network, i.e.:

a) to be connected directly to the termination of a public telecommunications network;
b) to interwork with a public telecommunications network being connected directly or indirectly to the termination of a public telecommunications network;

in order to send, process, or receive information.

4 General considerations

4.1 ONP Context

The regulatory framework of ONP is described in the Directive 90/387/EEC [2]. Particular aspects applicable to leased lines are covered by Directive 92/44/EEC [3]. ONP conditions are based on equality of access to public telecommunications networks or services.

The Directive 90/387/EEC [2] sets out a procedure leading up to the publication in the official journal of the European Community of standards deemed to be suitable for open and efficient access to public network or services.

4.2 SDH leased line service clarifications

The following subclauses analyse and specify SDH leased line services.

4.2.1 SDH network architecture

The architecture of a SDH transport network is described in ITU-T Recommendation G.803 [7]. According to this Recommendation, SDH transport networks are built up of successive network layers. Each layer may provide transport to a client layer and may use transport provided by a server layer. Each layer maintains its own integrity and informs its client layers about its presence or absence (failure).

Figure 1 shows the different layers and their client/server relations:

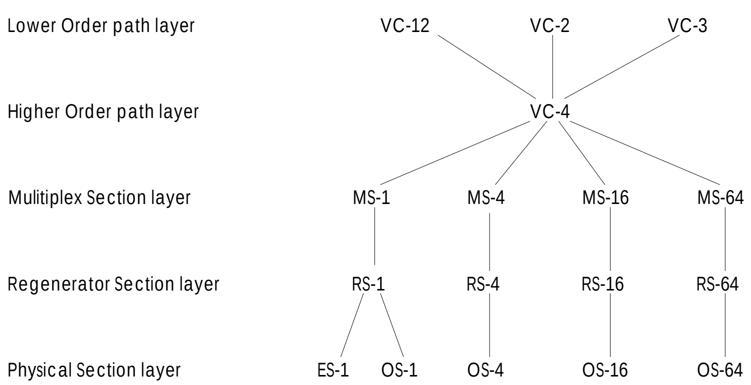


Figure 1: Layers of SDH networks

A STM-N signal is generated in one equipment and terminated in the very next downstream equipment within the network. The signal is transported in the section layer which may be media-dependent. A STM-N is not an end-to-end entity within the network. On the other side a Virtual Container-n (VC-n) is transported in a path layer. Path layers are independent of transmission media and may support telecommunication services.

Therefore SDH leased lines shall be based on the transmission of VC-n.

Figure 2 shows which layers are involved for a VC-3 leased line and where they are generated and terminated. In this example, three successive VC-4 paths support the VC-3 leased line connection. They are generated and terminated by the Terminal Equipments (TEs) and two Network Elements (NE). The VC-3 path is not terminated or generated within the leased line connection. For establishment of a particular path all layers below that path (server layers) must be generated at one end and terminated at the other end. For leased line applications a path is established at user equipment without user signalling to the leased line.

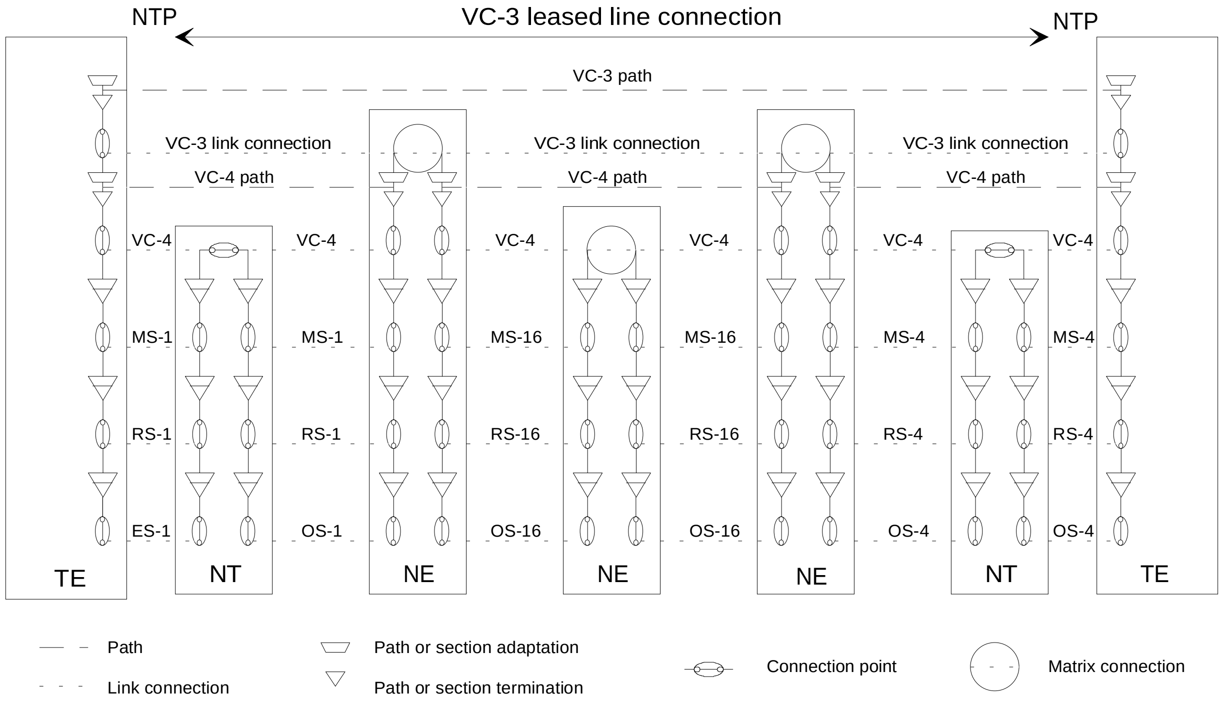


Figure 2: Example of a VC-3 path via a SDH leased line connection

The Lower Order (LO) and Higher Order (HO) path layers represent the leased lines which can be offered by SDH networks. Figure 3 shows the basic STM-1 frame and how it is structured into section overhead and the payload capacity containing the path layers.

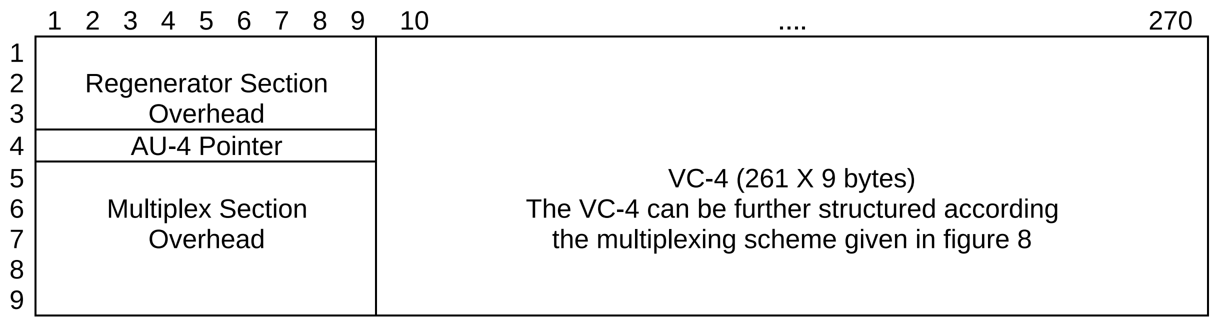


Figure 3: STM-1 frame and section overhead structure

4.2.1.1 Section layer

In general a section is formed between two adjacent equipments, but not all section layers need to be generated or terminated by each type of equipment. Details are given in the following subsections.

4.2.1.1.1 Physical section layer

This layer represents the electrical or optical characteristics of an interface. It is generated at the transmitter output of each equipment and terminated at the receiver input of the connected equipment.

4.2.1.1.2 Regenerator section layer

This layer is generated at the output of each regenerator or multiplexer and terminated at the input of the connected regenerator or multiplexer. It uses a number of bytes in the section overhead called Regenerator Section OverHead (RSOH).

4.2.1.1.3 Multiplex section layer

This layer is generated at the output of each multiplexer and terminated at the input of the connected multiplexer. It uses a number of bytes in the section overhead called Multiplex Section OverHead (MSOH). The MSOH is transferred transparently over regenerators.

4.2.1.2 Path layer

These layers form end to end connections. In principle they can be transported along an unlimited number of sections.

4.2.1.2.1 Higher order path layer

This layer is set on top of the multiplex section layer, i.e. the higher order path is directly multiplexed into the multiplex section.

4.2.1.2.2 Lower order path layer

These layers are set on top of the higher order path layer, i.e. lower order paths are multiplexed directly into the payload area of the higher order path.

4.2.2 VC-n formats and capabilities

ETS 300 147 [8] and ITU-T Recommendation G.709 [11] define the formats of the following VC-n: VC-11, VC-12, VC-2, VC-2-mc, VC-3, VC-4 and VC-4-Xc. Each VC-n includes a payload and a Path Overhead (POH). ITU-T Recommendation G.709 [11] describes the allocation of the path overhead.

Table 1: Overview of SDH path layer

Type of SDH path layer	Bit rate including POH	Main use today in European networks	Other possible use
VC-11	1 664 kbit/s	not used	
VC-12	2 240 kbit/s	2 048 kbit/s (Plesiochronous Digital Hierarchy) PDH signals	Asynchronous Transfer Mode (ATM) cells
VC-2	6 848 kbit/s	not used	ATM cells
VC-2-mc	m 6 848 kbit/s	not used	ATM cells, video signals
VC-3	48 960 kbit/s	34 368 kbit/s PDH signals	ATM cells
VC-4	150 336 kbit/s	139 264 kbit/s PDH signals lower order SDH VC-n	ATM cells Distributed Queued Dual Bus (DQDB) signals
VC-4-Xc	X 150 336 kbit/s	not used	ATM cells

A VC-n transmitted across a SDH leased line is generated and terminated outside the leased line connection. This includes in particular the POH. Any byte or bit of the POH which is payload dependant is transmitted transparently by the leased line with no restriction on the binary content.

4.2.2.1 VC-12

The VC-12 is widely used to transport 2 048 kbit/s PDH signals. It may also be used to transport ATM cells.

4.2.2.2 VC-2

The VC-2 is not used today in European public networks, since their is no signal of the European PDH hierarchy which corresponds to that VC capacity. In principle the VC-2 might be used to transport ATM cells, 6 312 kbit/s signals of the American PDH or signals of similar bandwidth.

NOTE: The bitrate of the next level above the 2 048 kbit/s signal in the European PDH (8 448 kbit/s) is too high for a VC-2.

4.2.2.3 VC-3

In Europe the VC-3 is normally used to transport 34 368 kbit/s PDH signals. Due to the large difference in bandwidth between a 34 368 kbit/s signal and the transport capability of a VC-3, it is much more effective in a SDH environment to use VC-3 leased line connection than a 34 368 kbit/s connection. It may be used to transport ATM cells.

4.2.2.4 VC-4

This higher order VC provides a great number of standardised means to transport signals like:

- 140 Mbit/s signals;
- ATM cells;
- lower order SDH VC-n;
- DQDB signals.

4.2.2.5 PDH signals

SDH leased lines provide access to the VC-n bandwidth. The TEs which generate and terminate these VC-n may use the payload capacity to transmit PDH signals. These PDH signals are not accessible within the leased line connections.

5 Existing standards

The following subclauses present existing standards relevant to SDH leased line interface and connection characteristics. Further documentation on SDH transmission equipment is listed in ETR 239 [12].

5.1 Standards relevant to interfaces

Table 2 lists existing standards relevant to interface characteristics of SDH leased lines. These standards apply to the STM-N interface on which a SDH leased line is presented to a terminal equipment and the network at the NTP.

Table 2: Existing standards applicable to interface characteristics of SDH leased lines

Standard	Content of the standard applicable to interfaces of SDH leased line
ETS 300 147 [8] ITU-T Recommendations G.708 [10], G.709 [11]	Multiplexing of VC-n in STM-N interfaces
ETS 300 417 Parts 1-1 [13], 2-1 [14], 3-1 [15] and 4-1 [16] ITU-T Recommendation G.783 [17]	Functional characteristics of SDH equipment
prETS 300 462 [18] (Draft) ITU-T Recommendations G.825 [19], G.81s [20]	Timing and synchronisation of STM-N interfaces
ETS 300 166 [21] ITU-T Recommendation G.703 [22]	Electrical characteristics of STM-1 electrical interfaces
ETS 300 232 [23] ITU-T Recommendation G.957 [24]	Optical characteristics of STM-N optical interfaces
IEC 169/13 [25]	75 ohms coaxial connector (type 1,5/5,6)

5.2 Standards relevant to connection characteristics

Table 3 lists existing standards relevant to end-to-end connection characteristics of SDH leased lines.

Table 3: Existing standards applicable to connection characteristics of SDH leased lines

Standard	Content of the standard applicable to SDH leased line connections
ETS 300 147 [8] ITU-T Recommendation G.709 [11]	Structure of VC-n
ETS 300 417 Parts 1-1 [13], 2-1 [14], 3-1 [15] and 4-1 [16] ITU-T Recommendation G.783 [17]	Functional characteristics of SDH equipment
ITU-T Recommendation G.826 [26]	Error performance parameters and objectives
I-ETS 300 416 [27]	Availability
ETR 114 [28] ITU-T Recommendation G.803 [7]	Functional architecture of SDH transport networks

5.3 Relationships of the standards

Most of the standards listed in subclauses 5.1 and 5.2 make reference to other standards. Figure 4 shows these relationships and the approximate number of pages from each standard deemed to be relevant to SDH leased lines.

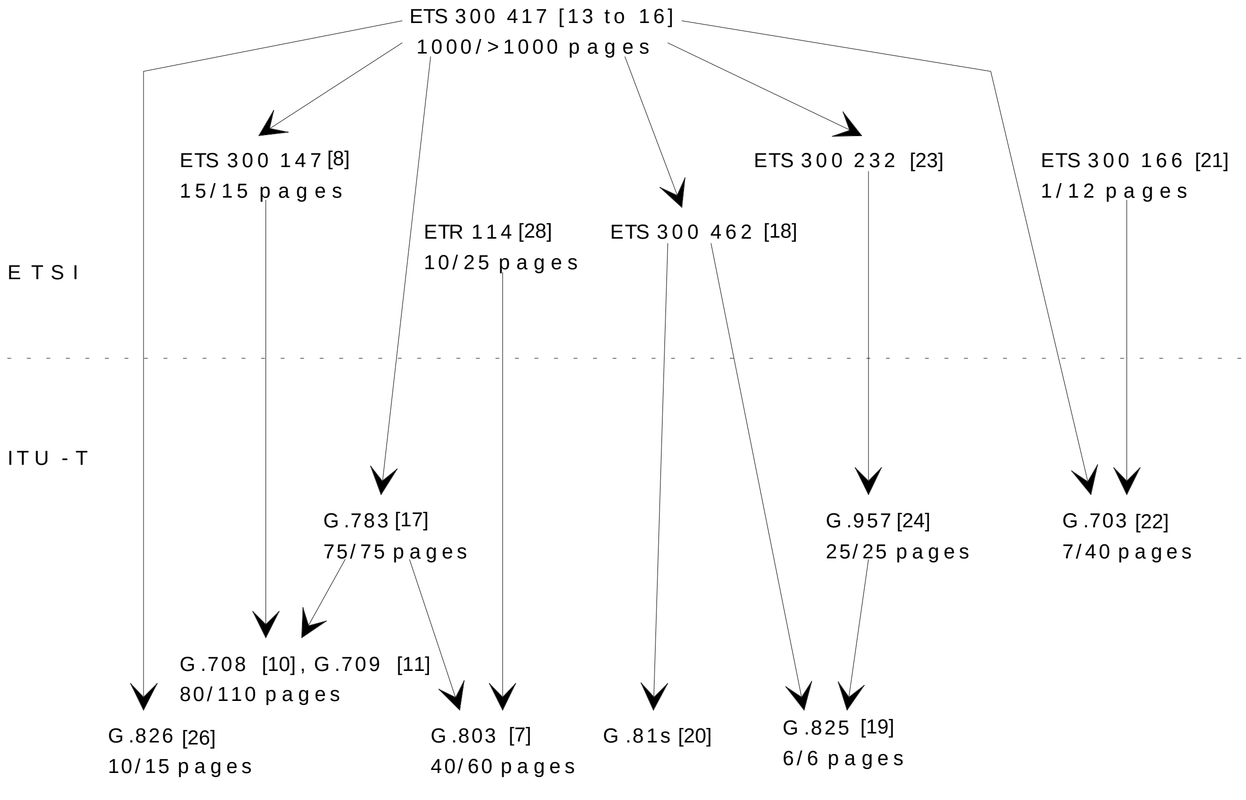


Figure 4: Relationships between standards

6 Examination of the technical requirements

Four types of VC-n are proposed for leased line applications: VC-12, VC-2, VC-3 and VC-4. Their transport capacities in terms of bit rate are shown in table 4.

Table 4: Transport capacity of VC-n proposed for SDH leased lines

Type of SDH path layer	Bit rate including POH	Bit rate of payload
VC-12	2 240 kbit/s	2 176 kbit/s
VC-2	6 848 kbit/s	6 784 kbit/s
VC-3	48 960 kbit/s	48 384 kbit/s
VC-4	150 336 kbit/s	149 760 kbit/s

The provision of leased lines supporting VC-2 which are concatenated virtually (VC-2-mc) or VC-4 which are concatenated (VC-4-Xc) may be considered when the implementation of the needed functions is achieved within European SDH networks.

6.1 Connection arrangements

A leased line connection forms a transport capability for a SDH path from one Network Termination (NT) to another NT, i.e. it is a point to point connection. However, the NTs do not terminate the path to be transported via the leased line connection but terminate all server layers.

This point to point characteristics does not constrain the presentation of several connections at one physical interface. STM-N physical interfaces are capable of presenting a wide range of telecommunications services. A given interface may present a collection of several different leased lines to one or more different destinations, or a combination of one or more leased lines and access to other services (e.g. Primary Rate Access ISDN (PRA-ISDN) or Broadband Integrated Services Digital Network (B-ISDN)).

Consequently the interfaces at the different ends of a SDH leased line may contain different combinations of services.

The scope and contents of the standards should provide the modularity necessary to cover the combinations of services that may be presented in practice.

6.1.1 Sharing of STM-N interfaces with other services

When a STM-N interface presents one or more leased lines together with other services, some VC-n are used for leased lines and other VC-n are used for the other services.

6.1.2 STM-N interfaces with multiple leased line connections

Figure 5 illustrates an example of such a configuration. SDH leased line connections may originate at one single STM-N physical interface and terminate in different STM-N physical interfaces.

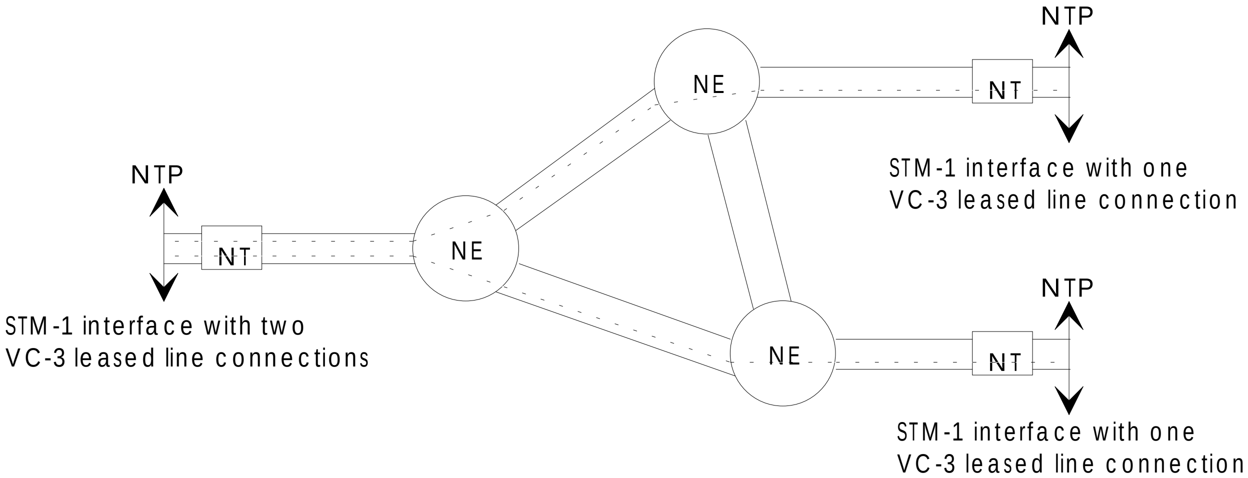


Figure 5: Example of more than one connection combined on one single physical interface

6.2 Timing and synchronisation

Pointer adjustments cause phase steps on the VC-n payload. The limitations to these phase steps need further consideration. Subclause 11.3 of ETS 300 417-1-1 [13] defines the sequences of pointers adjustments which shall be tolerated by any SDH equipment with PDH interfaces.

The synchronisation source for SDH leased line TE should, under normal conditions, be traceable to a Primary Reference Clock (PRC) as described in part 6 of prETS 300 462 [18]. This would therefore restrict the net occurrence of AU and TU pointer justification events to a rate which is proportional to the frequency difference between the SDH leased line source and sink TEs. Note that even if both TEs were synchronised, then AU and TU pointer justification events would still occur in a random manner as a result of noise accumulation in the synchronisation distribution network.

Part 2 of prETS 300 462 [18] describes methods for distributing timing to SDH network elements throughout SDH transport networks. The preferred method is using the STM-N optical bearer. A timing reference derived from the STM-N line rate should be traceable to the public network operator's clock which is compliant with a PRC and could be used to synchronise the SDH leased line TE.

PDH signals carried within the VC-n path layer will also exhibit jitter and wander due to pointer justification events and therefore care should be taken if these PDH signals are to be used to synchronise private network equipment e.g. a Private Automatic Branch eXchange (PABX). In particular if a private network is distributing synchronisation to a number of nodes using 2 Mbit/s transport over a number of concatenated SDH leased lines, then wander accumulation may exceed the limits defined in ITU-T Recommendation G.823 [6]. Part 2 of prETS 300 462 [18] recommends that PDH signals transported over SDH networks are not used for dissemination of timing information within public networks.

NOTE: Timing requirements for SDH leased lines delivered over a PDH interface (see annex D) would require further investigation.

6.3 Interface characteristics

STM-N interfaces are defined in ETS 300 147 [8] in accordance with ITU-T Recommendations G.707 [9] and G.708 [10]. Standardised values of N are 1, 4, 16 and 64. The provision of STM-1 and STM-4 interfaces is appropriate for the interface presentation of SDH leased lines.

The corresponding SDH hierarchical bit rates are:

- STM-1: 155 520 kbit/s;
- STM-4: 622 080 kbit/s.

Figures 6 and 7 show the structure of these signals.

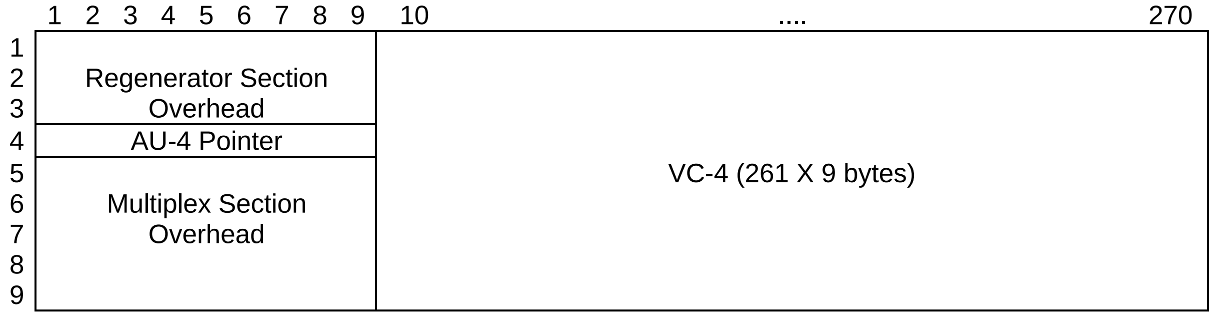


Figure 6: Frame structure of the STM-1 signal

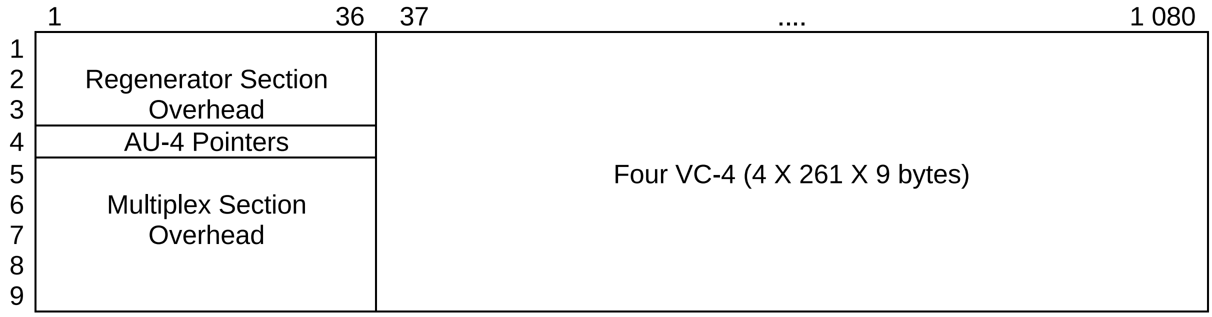


Figure 7: Frame structure of the STM-4 signal

STM-1 and STM-4 interfaces should always present 1 or VC-4S respectively. These VC-4S can represent SDH leased lines (transparent through the connection) or can carry a combination of lower order VC-n associated to one or more SDH leased lines. In the latter case the VC-4 will not be transported transparently across the network.

Figure 8 shows the multiplexing structure of these signals:

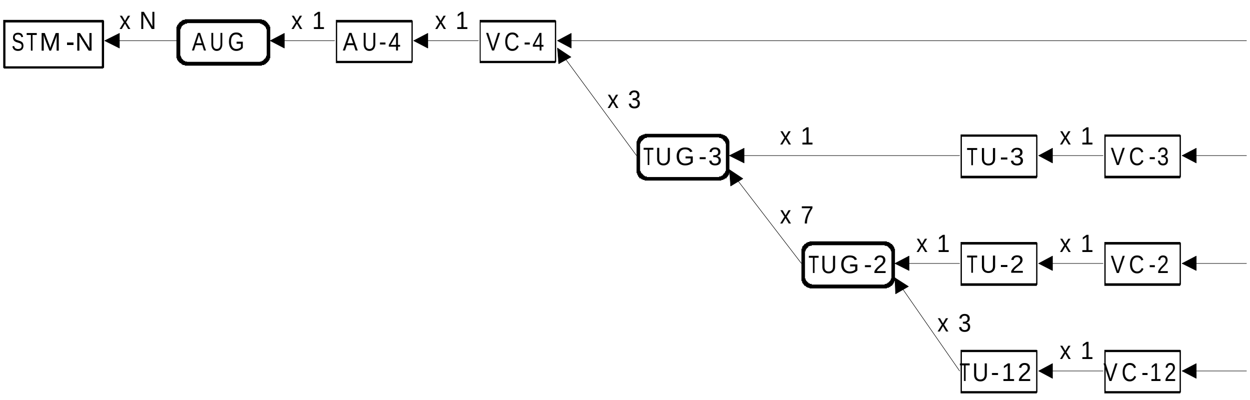


Figure 8: Multiplexing structure of a STM-N frame

A VC-4 can contain for example:

- 63 VC-12; or
- 3 VC-3; or
- 2 VC-3 and 21 VC-12; or
- 1 VC-3 and 42 VC-12;
- etc..

All unused VC-n within the STM-N interface are presented as valid unequipped VC-n as defined in ITU-T Recommendation G.709 [11].

Appropriate limitations on combinations of VC-n at the interface may need to be defined in order to limit equipment complexity. In particular, consideration should be given to assignments of VC-n. They should be assigned sequentially as described in annex E in the absence of any other agreement between the leased line provider and the user.

6.3.1 Physical layer characteristics

Electrical characteristics of STM-1 interfaces are defined in ETS 300 166 [21] in accordance with ITU-T Recommendation G.703 [22].

Optical characteristics of STM-1 and STM-4 interfaces are defined in ETS 300 232 [23] in accordance with ITU-T Recommendation G.957 [24].

6.3.2 Physical connection method

When the leased line interface presentation is a STM-1 electrical interface, the same physical connection method as for 34 and 140 Mbit/s leased lines is proposed:

a) coaxial 75 Ω connector (type 1,6/5,6) complying with IEC 169/13 [25]; or
b) coaxial 75 Ω Bayonet Nut Connector (BNC).

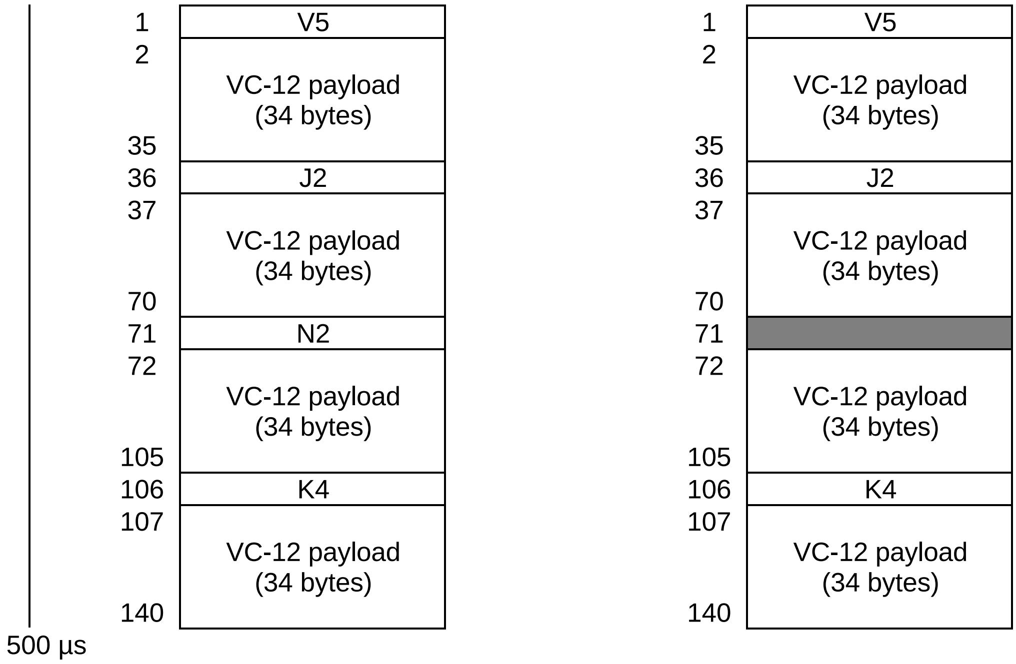
When the leased line interface presentation is a STM-1 or STM-4 optical interface, a specific connection method is not proposed for the following reasons:

- the diversity of standardised optical connectors already used within Europe;
- to specify a single type of optical connector would not be a great advantage because it is comparatively easy to fit different types of connectors at each end of a short length of fibre.

6.4 Connection characteristics

6.4.1 VC-n structures

Figure 9 to figure 12 show the structure of VC-12, VC-2, VC-3 and VC-4 and its overhead bytes. These structures are defined in ITU-T Recommendation G.709 [11]. The bytes of a VC-3 and VC-4 are transmitted with a frequency of 8 kHz, i.e. the frame length is 125 µs. The VC-12 and the VC-2 are mapped into a multiframe of a length of 500 µs.

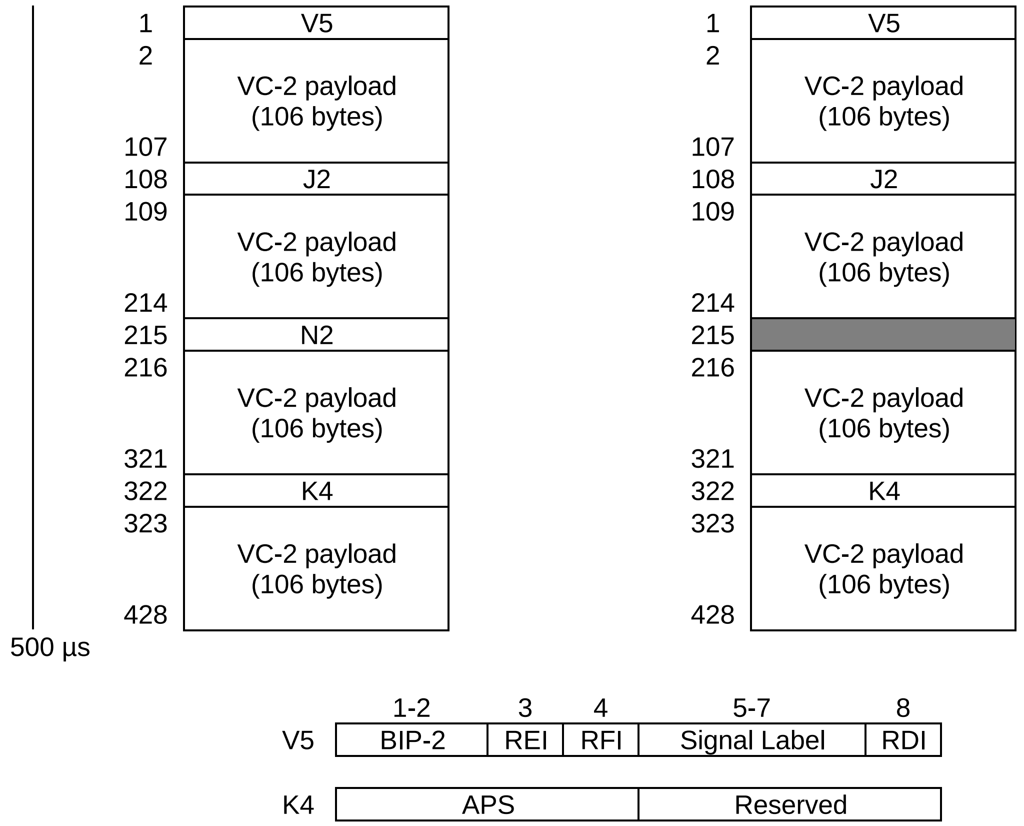


	1-2	3	4	5-7	8
V5	BIP-2	REI	RFI	Signal Label	RDI

K4	APS	Reserved

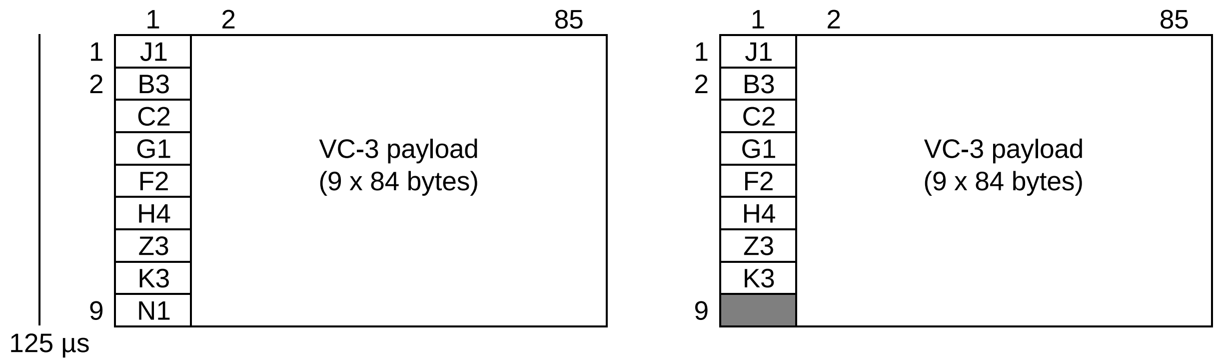
NOTE: Although the contents of Bit Interleaved Parity-2 (BIP-2) in byte V5 may change through tandem connection monitoring processes, the parity information of BIP-2 is passed transparently through the leased line.

Figure 9: Structure of a VC-12 (left) and part of VC-12 which is transmitted transparently (right)



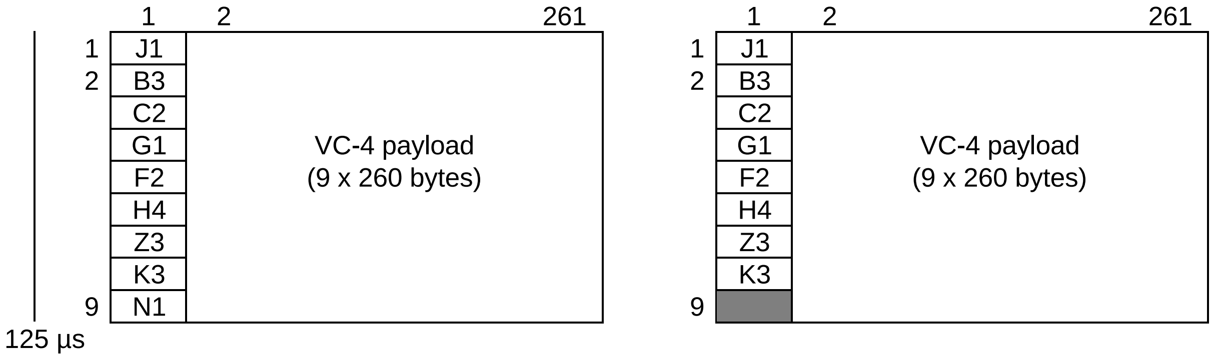
NOTE: Although the contents of BIP-2 in byte V5 may change through tandem connection monitoring processes, the parity information of BIP-2 is passed transparently through the leased line.

Figure 10: Structure of a VC-2 (left) and part of VC-2 which is transmitted transparently (right)



NOTE: Although the contents of B3 may change through tandem connection monitoring processes, the parity information of B3 is passed transparently through the leased line.

Figure 11: Structure of a VC-3 (left) and part of VC-3 that is transmitted transparently (right)



NOTE: Although the contents of B3 may change through tandem connection monitoring processes, the parity information of B3 is passed transparently through the leased line.

Figure 12: Structure of a VC-4 (left) and part of VC-4 that is transmitted transparently (right)

6.4.2 VC-n overhead functions

The functions of the VC-n path overhead are described in the following subclauses.

6.4.2.1 VC-12 and VC-2

6.4.2.1.1 End-to-end communication overhead with independent payload function

Bits 3, 4 and 8 of V5: path status.

Bits 1 and 2 of V5: BIP-2 of the previous VC multiframe.

Byte J2: access point identifier (unique number of the path).

Bits 5 to 7 of V5: payload type.

Bits 1 to 4 of K4: Automatic Protection Switching (APS) protocol for path protection.

6.4.2.1.2 Overhead which can be overwritten in an operator domain

Byte N2: network operator byte, may be used for tandem connection monitoring.

6.4.2.1.3 Overhead reserved for future standardisation

Bits 5 to 8 of K4: reserved for future standardisation.

6.4.2.2 VC-3 and VC-4

6.4.2.2.1 End-to-end communication overhead with independent payload function

Byte J1: access point identifier (unique number of the path).

Byte B3: BIP-8 of the previous VC frame.

Byte C2: payload type.

Byte G1: path status.

Bits 1 to 4 of K3: Automatic Protection Switching (APS) protocol for path protection.

6.4.2.2.2 Payload type specific overhead

Bytes F2 and F3: user channels.

Byte H4: user channel or position indicator dependant on payload type.

6.4.2.2.3 Overhead reserved for future standardisation

Bits 5 to 8 of K3: reserved for future standardisation.

6.4.2.2.4 Overhead which can be overwritten in an operator domain

Byte N1: network operator byte, may be used for tandem connection monitoring.

6.4.3 VC overhead allocation for leased line services

The path overhead (POH) of a VC-n transmitted across a leased line is generated and terminated at user equipment. A leased line connection should transport a VC transparently, except the network operator byte N1/N2 and the BIP. However the end to end performance monitoring capability of the BIP is retained.

The VC-n path overhead (POH) is used for several means:

- end to end performance monitoring and path status supervision;
- end to end protection switching;
- end to end signalling for any means;
- performance monitoring and status supervision at intermediate points along the path, e.g. at the NTPs of a leased line.

NOTE: Path status supervision is used for the detection and localisation of defects and degradation in order to have a quick repair of the path.

Some of the overhead bytes specified for the end to end performance monitoring and path status supervision are also needed to operate a VC-n leased line connection. The N1/N2 byte could be used by the leased line provider to determine the quality of received and transmitted path signals.

There should be no constrains on the payload dependant bytes/bits, i.e. the leased line connection should be transparent for them.

Undefined bits are currently transported transparently by the leased line connection but there it is unclear whether this will be done in the future.

6.4.4 Transmission delay

The same transmission delay requirements as specified for 34 and 140 Mbit/s leased lines should be applicable in the case of SDH leased lines.

6.4.5 Error performances

SDH leased line error performance objectives can be derived from ITU-T Recommendation G.826 [26]. This Recommendation defines the error performance parameters, gives the end-to-end error performance objectives of an international 27 500 km hypothetical reference path and describes an allocation methodology which can be used to deduce the error performance objectives of a particular path.

ITU-T Draft Recommendation M.2101 [29] specifies the performance limits for bringing into service and maintenance of a path. These limits may be used by the leased line provider as part of the commissioning to ensure that the error performance objectives are met.

6.4.6 Availability

I-ETS 300 416 [27] addresses the availability of paths based on PDH, SDH and other transport network such as cell-based. As this ETR is written in the ONP context, the standard level defined in I-ETS 300 416 [27] should be retained.

A higher level of availability would require protection switching and cause constraints on the TEs and on the path overhead capacity available to the user.

7 Conclusions on proposed standards

7.1 General conclusions

a) Within the SDH architecture, a leased line equates to the transmission of virtual containers, and the transmission of the following virtual containers (leased line capacities) should be specified:

- VC-12;
- VC-2;
- VC-3;
- VC-4.

Thus four leased line types should be covered.

b) Two network interface capacities should be specified, STM-1 and STM-4, with STM-1 in both electrical and optical forms, and STM-4 in optical form (there is no specification for an electrical form);

c) The standards should ensure modularity between the interface and leased line types so that any of the leased line types may be presented in any of the interface types. Furthermore, where the capacity of the interface permits, it should be possible for a number of different leased lines to different destinations, and other non-leased line services, each in separate virtual containers, to be presented at the same network interface.

7.2 Proposed standards

The following standards should be produced:

ETS A: An interface presentation standard for the interface covering both STM-1 and STM-4 interfaces with STM-1 in both electrical and optical forms, and STM-4 in optical form. This standard should cover the interface characteristics from the physical layer through to the section layer, i.e.:

- the physical characteristics;
- the timing and synchronisation;
- the STM-N frame structure and the VC-4 to STM-N mapping;
- the multiplexing of VC-12, VC-2, and VC-3 into VC-4 for use on the section between the TE and the NT;
- the VC combinations.

Because each side of the interface is identical, this standard should apply to both the network and terminal equipment sides of the interface.

ETS B: A connection characteristics standard that defines the VC structure for transmission across the leased line, and the NTP-NTP performance for each of the VC-12, VC-2, VC-3 and VC-4 containers.

ETS C: A TE standard that defines the VC structure, path overhead and pointer adjustment requirements for connection to each of the leased line types. Both ETS A and ETS C would apply to a given TE interface.

The relationships of these standards are shown in the following figure:

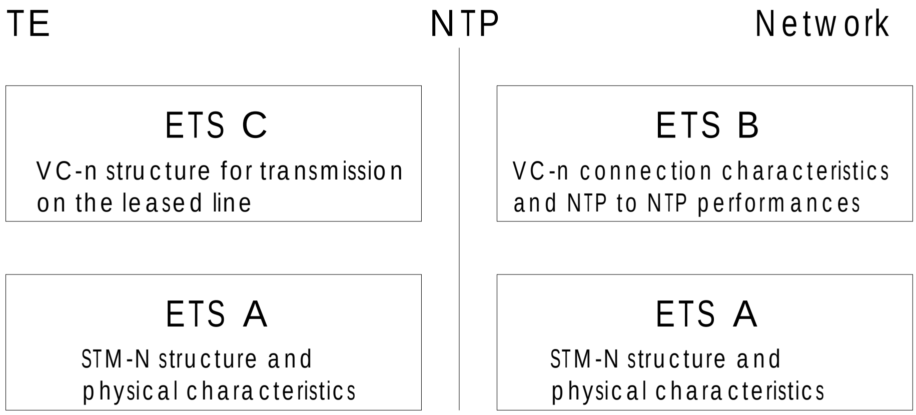


Figure 13: Relationships of the standards

These ETS are listed in annex A. Their proposed scopes and tables of contents are given in annex B.

This structure is similar to the approach taken for PDH ONP leased lines in respect of the network, where a similar distinction between the interface and connection characteristics exists, but without the modularity for different interface and connection types. However it is different in respect of the TE, where for the PDH cases there is a single terminal equipment interface standard that includes both the physical characteristics and the frame structure. Unlike the SDH interface, each side of the PDH interface is not identical.

Concerning the type approval of the terminals, it is recommended that pan-European market access should be assured. This could be achieved through a Technical Basis for Regulation (TBR), if TBRs continue to be used in the future. Any decision on the production of a TBR will have to take account of the changes to the approvals regime, since a TBR could not be produced to enter into force before 1998.

Because the SDH interfaces and frame structures are complex and are specified in "base" standards of considerable length, we recommend that where appropriate the standards to be produced should be written as selection menus that use normative references to the base standards, rather than as self contained documents that reproduce the requirements in the base standards. Tests should be referenced or developed for each of the requirements, and normative text should be distinguished from informative text.

7.3 Extent of the work to be done

Technical requirements specified in SDH leased line standards will be based on existing standards whenever possible. The work to be done will have to focus on pointer transfer characteristics which are not already standardised.

7.4 Work program

Table 5, reproduced in annex C, presents the proposed schedule for the production of the standards. A project team will probably be needed to support the progress of the work.

Table 5: Standard production schedule

Stage	Schedule
Up to Public Enquiry	12 months
Public Enquiry	4 months
Public Enquiry to Vote	4 months
Vote	2 months
TOTAL	**22 months**

8 Possible evolutions

These topics are described for possible future enhancements of the standards and are not proposed to be included at this time.

8.1 Unidirectional connections

Unidirectional connections might be possible in the future.

8.2 Point to multipoint connections

Point to multipoint connections might be possible in the future.

8.3 Reconfiguration of leased line connection

Reconfiguration of leased line connection will need detailed further study.

8.4 New interfaces

In the future STM-16 and even STM-64 interfaces could be foreseen, if it is justified by the bandwidth requirements. It is the advantage of layered networks that the connection characteristics of higher and lower order paths are not effected by the type of interface. The STM-16 and STM-64 interfaces could be added just by amending the interface standard.

The corresponding SDH hierarchical bit rates are:

- STM-16: 2 488 320 kbit/s;
- STM-64: 9 953 280 kbit/s.

Figures 14 and 15 show the structures of these signals:

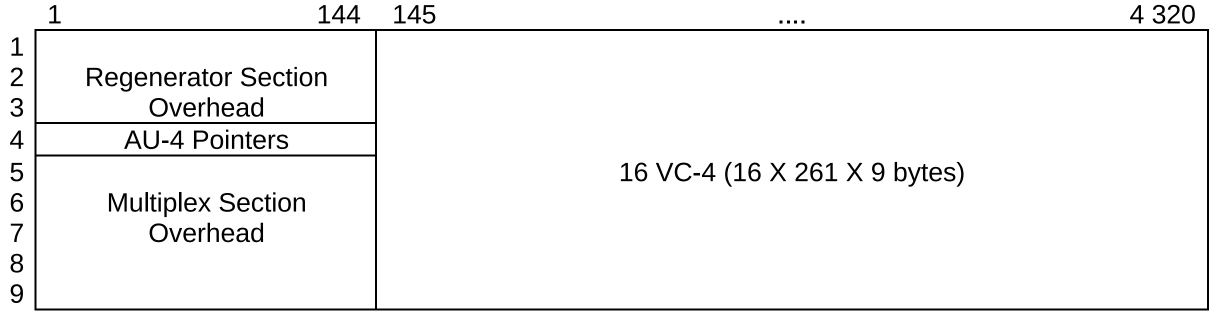


Figure 14: Frame structure of the STM-16 signal

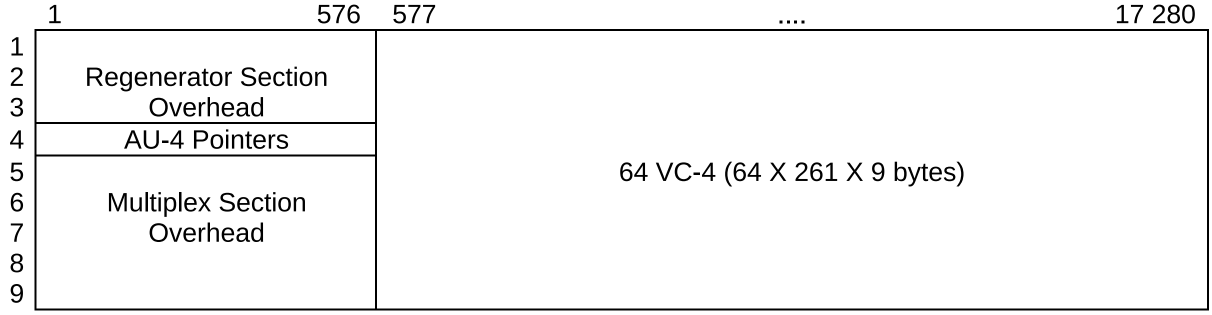


Figure 15: Frame structure of the STM-64 signal

8.5 Alternative PDH interfaces

ETS 300 337 [30] describes the transport of SDH VC-n (VC-12, VC-2, VC-3) at 34 368 kbit/s and 139 264 kbit/s. Therefore it would be possible to specify also PDH interfaces at these bit rates for the provision of SDH leased lines. Annex D details these interfaces.

8.6 Support of concatenated VC-n

The provision of leased lines supporting VC-2 which are concatenated virtually (VC-2-mc) or VC-4 which are concatenated (VC-4-Xc) may be considered when the implementation of the needed functions is achieved within European SDH networks.

Annex A: List of proposed SDH leased line standards

The titles of the proposed ETS are as follows:

Transmission and Multiplexing (TM);
SDH leased lines;
Network and terminal equipment interface presentation

Transmission and multiplexing (TM);
SDH leased lines;
Connection characteristics

Transmission and Multiplexing (TM);
SDH leased lines;
Terminal equipment VC-n presentation to SDH leased lines

Annex B: Proposed tables of contents and scopes

B.1 Network and terminal equipment interface presentation ETS

B.1.1 Scope

This ETS specifies the technical requirements and corresponding test principles for the interface presentations of Synchronous Digital Hierarchy (SDH) leased lines. These leased lines provide an information transmission capability based on SDH Virtual Containers (VCs) between Network Termination Points (NTPs).

This ETS defines the interface as presented by the leased line and by the terminal equipment. It covers the physical and functional characteristics of the interface.

This ETS is applicable to leased lines, including part time leased lines, for which the establishment or release do not require any protocol exchange or other intervention at the NTP.

This ETS is not intended for regulatory purposes.

Customer premises wiring and installation between the terminal equipment and the NTP are outside the scope of this ETS.

B.1.2 Contents

1 Scope

2 References

3 Abbreviations and Definitions

4 Requirements and tests

- 4.1 Physical characteristics
  - 4.1.1 STM-1 electrical interface
  - 4.1.2 STM-1 and STM-4 optical interfaces
- 4.2 Timing and synchronisation
- 4.3 Multiplexing structure
- 4.4 Leased line bandwidth assignment
- 4.5 Electromagnetic Compatibility (EMC)
- 4.6 Safety
  - 4.6.1 Electrical safety
  - 4.6.2 Optical safety

B.2 Connection characteristics ETS

B.2.1 Scope

This ETS specifies the technical requirements and corresponding test principles for connection characteristics of Synchronous Digital Hierarchy (SDH) leased lines. These leased lines provide an information transmission capability based on SDH Virtual Containers (VCs) between Network Termination Points (NTPs).

Signals transmitted across the leased line connections are subject to restrictions and impairments. The restrictions and the limits to impairments are stated in this ETS.

This ETS is applicable to leased lines, including part time leased lines, for which the establishment or release do not require any protocol exchange or other intervention at the NTP.

B.2.2 Contents

1 Scope

2 References

3 Abbreviations and Definitions

4 Requirements and tests

4.1 VC-12 connection

4.1.1 Structure

4.1.2 Path overhead functions

4.1.3 Pointer transfer characteristics

4.1.4 Transmission delay

4.1.5 Error performance

4.1.6 Availability

4.2 VC-2 connection

4.2.1 Structure

4.2.2 Path overhead functions

4.2.3 Pointer transfer characteristics

4.2.4 Transmission delay

4.2.5 Error performance

4.2.6 Availability

4.3 VC-3 connection

4.3.1 Structure

4.3.2 Path overhead functions

4.3.3 Pointer transfer characteristics

4.3.4 Transmission delay

4.3.5 Error performance

4.3.6 Availability

4.4 VC-4 connection

4.4.1 Structure

4.4.2 Path overhead functions

4.4.3 Pointer transfer characteristics

4.4.4 Transmission delay

4.4.5 Error performance

4.4.6 Availability

B.3 Terminal equipment VC-n presentation to SDH leased lines ETS

B.3.1 Scope

This ETS specifies the technical requirements and corresponding test principles for a terminal equipment interface for presentation of VC-n to Synchronous Digital Hierarchy (SDH) leased lines. These leased lines provide an information transmission capability based on SDH Virtual Containers (VCs) between Network Termination Points (NTPs).

B.3.2 Contents

1 Scope

2 References

3 Abbreviations and Definitions

4 Requirements and tests

4.1 VC-12

4.1.1 Structure

4.1.2 Path overhead functions

4.1.3 Pointer adjustments limitations

4.2 VC-2

4.2.1 Structure

4.2.2 Path overhead functions

4.2.3 Pointer adjustments limitations

4.3 VC-3

4.3.1 Structure

4.3.2 Path overhead functions

4.3.3 Pointer adjustments limitations

4.4 VC-4

4.4.1 Structure

4.4.2 Path overhead functions

4.4.3 Pointer adjustments limitations

Annex C: Proposed work program

Table C.1 shows the proposed schedule for the production of SDH leased line standards:

Table C.1: Standard production schedule

Stage	Schedule
Up to Public Enquiry	12 months
Public Enquiry	4 months
Public Enquiry to Vote	4 months
Vote	2 months
TOTAL	**22 months**

Annex D: Alternative PDH interfaces

ETS 300 337 [30] defines the frame structures and the multiplexing arrangements in order to transport VC-n at the following PDH hierarchical bit rates:

- 34 368 kbit/s;
- 139 264 kbit/s.

The provision of leased lines based on the transmission of VC-n between PDH interfaces at the NTP is not precluded.

Figure D.1 and D.2 show the corresponding synchronous frame structures. The VC-n are multiplexed into the PDH signals differently than into a STM-N signal. These interfaces can only present lower order SDH paths.

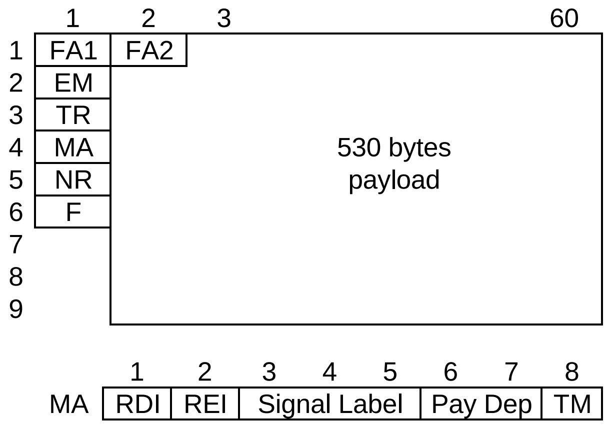


Figure D.1: 34 368 kbit/s frame structure

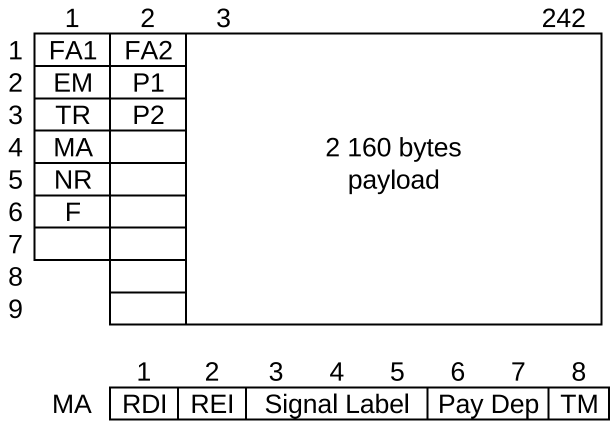


Figure D.2: 139 264 kbit/s frame structure

The 34 368 kbit/s interface supports 14 VC-12.

The 139 264 kbit/s interface can present:

- 2 VC-3 and 15 VC-12; or
- 60 VC-12; or
- 1 VC-3 and 36 VC-12.

Figure D.3 shows the multiplexing structure of the 139 264 kbit/s interfaces.

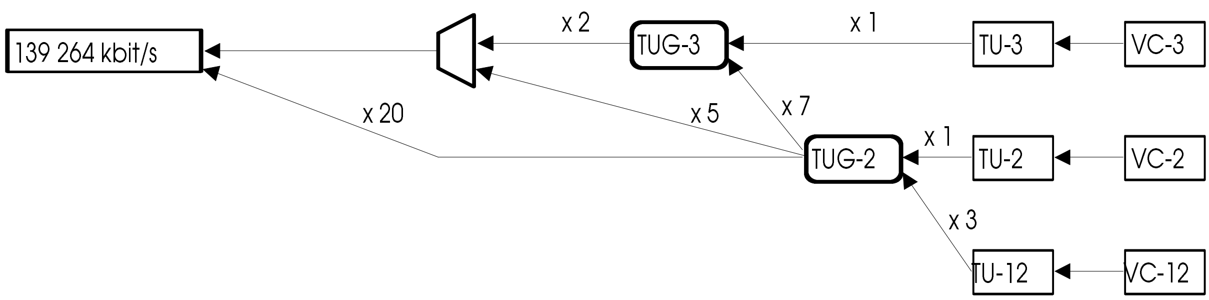


Figure D.3: Multiplexing of lower order VC-n into a 139 264 kbit/s signal

Annex E: Assignment of VC-n at leased line interfaces

E.1 Assignment of VC-4 in STM-4 interfaces

VC-4 should be assigned in the order from VC-4 #1 to VC-4 #4 within a STM-4. However in agreement with the leased line provider a different assignment could be applied.

E.2 Assignment of VC-3 and TUG-3 in a VC-4

VC-3/TUG-3 should be assigned in the order from VC-3 #1 to VC-3 #3 within a VC-4. For STM-N interfaces (N>=4) an Administrative Unit Group (AUG) should be completely filled before a VC-3 or TUG-3 is assigned to a further AUG. However in agreement with the leased line provider a different assignment could be applied.

NOTE: An AUG forms an unit with various sub-units (TU-3, TU-2 and TU-12). There is no need to implement all types of Tributary Unit-n (TU-n) (down to TU-12) in an AUG. Time slot assignment in the specified way would permit to use the VC-4s with the minimum hardware and software functions.

E.3 Assignment of VC-2 and TUG-2 in a TUG-3

VC-2s/TUG-2s should be assigned in the order from VC-2 #1 to VC-2 #7 within a TUG-3. A TUG-3 should be completely filled before a VC-2 or TUG-2 is assigned to a further TUG-3. However in agreement with the leased line provider a different assignment could be applied.

NOTE: A TUG-3 forms an unit with various sub-units (TU-2 and TU-12). There is no need to implement all types of TU-n (down to TU-12) in a TUG-3 or TUG-2. Time slot assignment in the specified way would permit to use TUG-3s with the minimum hardware and software functions.

E.4 Assignment of VC-12 in a TUG-2

VC-12 should be assigned in the order from VC-12 #1 to VC-12 #3 within a TUG-2. A TUG-2 should be completely filled before a VC-12 is assigned to a further TUG-2. However in agreement with the leased line provider a different assignment could be applied.

NOTE: A TUG-2 forms an unit with up to three sub-units (TU-12). There is no need to implement TU-12s in all TUG-2s. Time slot assignment in the specified way would permit to use TUG-2s with the minimum hardware and software functions.

History

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