RECOMMENDATION ITU-R S.1149-1

NETWORK ARCHITECTURE AND EQUIPMENT FUNCTIONAL ASPECTS OF DIGITAL SATELLITE SYSTEMS IN THE FIXED-SATELLITE SERVICE FORMING PART OF SYNCHRONOUS DIGITAL HIERARCHY TRANSPORT NETWORKS

(Question ITU-R 201/4)

(1995-1997)

The ITU Radiocommunication Assembly,

considering

a)	that ITU-T Recommendation G.707 specifies bit rates, multiplexing structures and detailed mappings of tributaries in a new digital multiplex technique, known as the synchronous digital hierarchy (SDH);

b)	that digital satellite systems will remain as constituent elements of public/private networks in which SDH-based transmission technologies and SDH transport networks are being introduced;

c)	that ITU-T Recommendations G.803 and G.805 define the technology independent architecture of SDH transport networks;

d)	that ITU-T Recommendation G.780 defines the terminology of SDH and that ITU-T Recommendations G.781, G.782 and G.783 specify the general characteristics and functions of synchronous multiplexing equipment;

e)	that ITU-T Recommendations G.703 and G.957 respectively define the physical parameters of the electrical and optical interfaces of SDH equipment;

f)	that ITU-T Recommendations G.831, G.784 and G.774 define the management capabilities of SDH transport networks, the management functions and protocols of SDH networks and the management information model from the network element viewpoint;

g)	that integration with the Telecommunications Management Network TMN, defined in ITU-T Recommendation M.3000 "Overview of TMN Recommendations", is required;

h)	the on-going ITU-T studies on principles and guidelines for the integration of satellite and radio systems in SDH Transport Networks, including the concept of point-to-multipoint topologies, hereafter referred to as the "ITU-T Recommendation G.861 radio and satellite SDH integration guidelines";

j)	that the multidestination and multipoint capabilities of satellite systems are in common use because of their operational advantages;

k)	that Recommendations ITU-R F.750 and ITU-R F.751 define architectures, functional aspects, and transmission characteristics and performance of radio-relay systems in SDH based networks;

l)	that ITU-T Recommendation G.832 defines the method of transporting SDH elements over plesiochronous digital hierarchy (PDH) networks but that interconnection and interworking between PDH and SDH networks may be handled differently within a satellite system providing that the external interfaces and functionalities are compatible with terrestrial systems;

m)	the on-going ITU-R studies on transmission systems, its performance, multiple access methods and OAM aspects of digital satellite systems in the fixed-satellite service (FSS) forming part of SDH transport networks,

recommends

1	that digital satellite systems in the FSS comply with the network architecture and equipment functional requirements described in this Recommendation to permit integration into SDH transport networks.

CONTENTS

1 Introduction

1.1 Scope

This Recommendation addresses network architecture and equipment functions relevant for the design of synchronous digital satellite systems in the FSS forming parts of, or providing synchronous interconnections between, transport networks based on the SDH.

A general architectural diagram of FSS systems with SDH network transport capability is shown in Fig. 1. The basic requirement is transparent transport of SDH signal elements (virtual containers) through the satellite system.

This Recommendation focuses on SDH functionalities in the satellite system synchronous baseband equipment (SBE) necessary to realize three different scenarios for satellite system integration in SDH transport networks:

Scenario 1: SDH digital section

Scenario 2: wide-area single-rate cross-connect (common internal section bit rate of 51.84 Mbit/s)

Scenario 3: wide-area multi-rate cross-connect (a range of internal section bit rates <51.84 Mbit/s)

This Recommendation follows the "ITU-T Recommendation G.861 radio and satellite SDH integration guidelines", as well as other relevant G-series SDH Recommendations.

FIGURE 1

General FSS-SDH network architecture
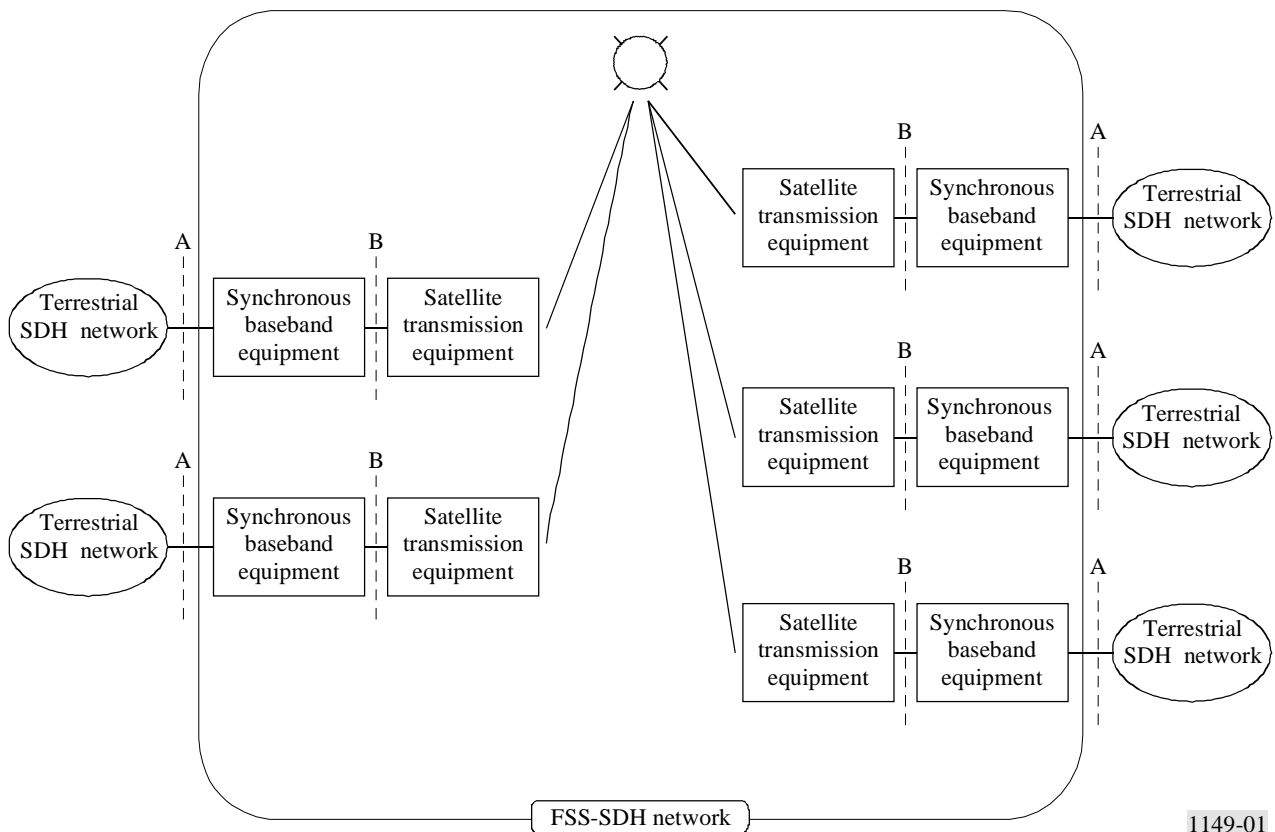
NOTE 1 – Synchronous baseband equipment and satellite transmission equipment are illustrated as separate units for the purpose of explanation; they may be implemented physically as one unit.

NOTE 2 – Reference point A: open EI for scenario 1; NNI and NNRP for scenarios 2 and 3.

NOTE 3 – Reference point B: SRP and open SEI for scenarios 1 and 2, SRP and closed SEI for scenario 3 (see the "ITU-T Recommendation G.861 radio and satellite SDH integration guidelines").

The basic functions of the SBE are one or more of the following, depending on the scenario:

– perform SDH multiplex set of functions, adapted to satellite applications and dependent on scenario;

– conversion and adaptation of section and path layers to satellite system internal interfaces or reference points;

– establishment of section and possibly path layer asymmetrical multidestination connections, and support point-to-point symmetrical path layer cross-connected connections;

– perform specific section functions for signal transmission over the satellite medium;

– integration of SDH pointer and satellite system timing;

– SBE SDH multiplex based management functions.

The basic functions of the satellite transmission equipment are:

– modem functions;

– multiple access system protocols, procedures and their management functions;

– timing preservation.

1.2   Abbreviations

AIS: alarm indication signal

APS: automatic protection switching

AU: administrative unit

AUG: administrative unit group

BIP: bit interleaved parity

DCC: data communication channel

DXC: digital cross connect

EI: equipment interface

FDMA: frequency division multiple access

HOVC: higher order virtual container

HPA: higher order path adaptation

HPC: higher order path connection

HPOM: higher order path overhead monitor

HPT: higher order path termination

HSPA: higher order satellite path adaptation

HSPT: higher order satellite path termination

HSSA: higher order satellite section adaptation

HSUG: higher order supervisory unequipped generator

HSUM: higher order supervisory unequipped monitor

IOS: intra-office section

ISI: internal satellite interface

LOVC: lower order virtual container

LPA: lower order path adaptation

LPC: lower order path connection

LPOM: lower order path overhead monitor

LPT: lower order path termination

LSSA:	lower order satellite section adaptation
LSUG:	lower order supervisory unequipped generator
LSUM:	lower order supervisory unequipped monitor
LT:	line termination
MCF:	message communications function
MDSS:	multi-destination satellite server
MSA:	multiplex section adaptation
MSOH:	multiplex section overhead
MSP:	multiplex section protection
MST:	multiplex section termination
NNI:	network node interface
NNRP:	network node reference point
OAM:	operation, administration and maintenance
OHA:	overhead access
PDH:	plesiochronous digital hierarchy
POH:	path overhead
RDI:	remote defect indication
REI:	remote error indication
RSOH:	regenerator section overhead
RST:	regenerator section termination
SBE:	synchronous baseband equipment
SDH:	synchronous digital hierarchy
SEI:	satellite equipment interface
SETPI:	synchronous equipment timing physical interface
SETS:	synchronous equipment timing source
S-IOS:	satellite intra-office section
SOH:	section overhead
SPI:	synchronous physical interface
SRP:	satellite reference point
SRT:	satellite regenerator termination
SSOH:	satellite section overhead
SSPI:	synchronous satellite physical interface
SST:	satellite section termination
SSTM-n:	satellite synchronous transport module-n
STM-N:	synchronous transport module-N
STUG-ij:	satellite tributary unit group ij
TDMA:	time division multiple access
TMN:	telecommunication management network
TU:	tributary unit
TUG:	tributary unit group
VC:	virtual container
VOW:	voice order wire

1.3   Definition of satellite specific terms

HSPA: higher order satellite path adaptation – a higher order adaptation function within the satellite system synchronous baseband equipment.

HSPT: higher order satellite path termination – a higher order path termination function within the satellite system synchronous baseband equipment.

HSSA: higher order satellite section adaptation – a higher order section adaptation function within the satellite system synchronous baseband equipment.

ISI: internal system interface – a system specific internal interface which is not subject to standardization.

LSP: lower order satellite path – a lower order path through the satellite system.

LSSA: lower order satellite section adaptation – a lower order section adaptation function within the satellite system synchronous baseband equipment.

MDSS: multidestination satellite server layer – the layer in the model which represents the multidestination capability of the satellite transmission system.

SFCOH: satellite frame complementary overhead – an overhead to the baseband composite signal to accommodate satellite transmission system's OAM functions (e.g. modem alarms and VOW).

S-IOS: satellite intra office section – an SDH section which is internal to the satellite system and which may have multipoint topology. It may cover a wide geographical area.

SLT: satellite line terminal – performs normal RST, MST and MS APS functions on the satellite side of the NNI.

SRP: satellite reference point – the point between the synchronous baseband equipment and the satellite transmission equipment.

SSOH: satellite section overhead – the overhead used within the satellite section between the synchronous baseband equipment.

SSPI: satellite synchronous physical interface – the physical interface between the synchronous baseband equipment and the satellite transmission equipment.

SST: satellite section termination – the function where the section overhead may be manipulated.

SS-TDMA: satellite switched time-division multiple access – a fixed TDMA system with on-board burst-to-burst cyclic inter-beam connection reconfigurations.

SSTM-n: satellite synchronous transport module order n – similar to STM-n of terrestrial transport systems but consisting of STUG payload multiplex and satellite section specific overhead.

STUG-ij: satellite tributary unit group ij – similar to a terrestrial tributary unit group TUG but represents a new multiplexing stage in between the G.708 TUG-2 level and TUG-3/VC-3 level.

2   SDH transport network description

2.1   SDH multiplexing techniques

### 2.1.1   Basic structure

The basic SDH multiplexing techniques (bit rates, frame formats and structures) are described in ITU-T Recommendation G.707. The SDH multiplex hierarchy has a level 1 bit rate of 155.52 Mbit/s (STM-1) as well as higher levels currently defined as STM-4 (622.080 Mbit/s) and STM-16 (2.48832 Gbit/s) formed by byte interleaving hierarchically lower synchronous multiplex signals.

Figure 2 shows the basic 125 μs frame structure of the STM-1 signal in a 270 × 9 bytes matrix format.

FIGURE 2

STM-1 (155.52 Mbit/s) frame structure
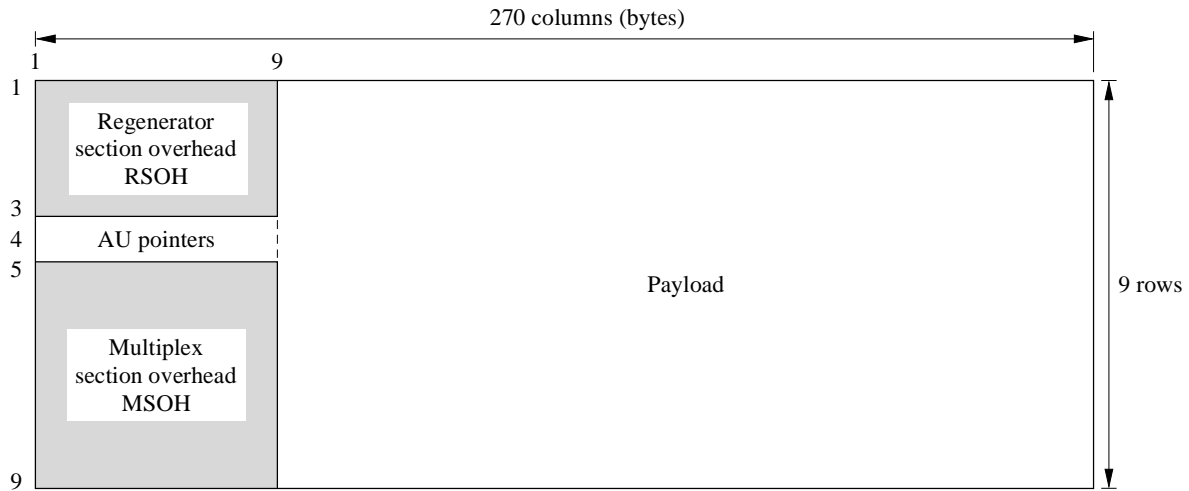
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The smallest SDH synchronous tributary signal element defined in the STM-1 multiplex is VC-12 (virtual container-12) having a payload capacity of 2.240 Mbit/s and a 64 kbit/s capacity per frame for its 4-byte POH, which is spread over a 4-frame multiframe. End-to-end transparency at the VC level is available to the SDH network users. Lower order paths (LOVC) and higher order path (HOVC) are defined, which can be flexibly configured and set up, through remote management operation, on a network-edge-to-network-edge, or node-to-node basis. HOVCs are either VC-4s or VC-3s. The supported LOVCs are then VC-3, VC-2 and VC-12, or VC-2 and VC-12 respectively.

Network nodes in SDH are interconnected by multiplex sections, which in turn may consist of a number of regenerator sections. Internode management is facilitated by functions communicated within multiplex section overhead (MSOH) and regenerator section overhead (RSOH). The allocation of section overhead (SOH) capacity and byte allocation to various management functions and the functions and protocols are described in ITU-T Recommendations G.707 and G.784.

2.1.2 Sub-STM-1 multiplex signals for radio systems

The construction of lower than STM-1 SDH multiplex signal bit rates for satellite system transmission follows the interworking multiplexing tree of Fig. 3, derived from the "ITU-T Recommendation G.861 radio and satellite SDH integration guidelines", with the addition of satellite tributary unit groups (STUGs). STUGs signal elements (multiplex groups) of different sizes are used as baseband signals of the satellite transmission equipment (FDMA or TDMA).

In all cases, the following principles shall be adhered to in constructing sub-STM-1 satellite multiplex signals:

– byte orientation of the multiplexed signals;

– transparency to the lowest order basic SDH signal elements (VCs, TUs) as a minimum;

– provision of SDH section overhead functionalities, including OAM and network management across the satellite transmission paths and between the SDH baseband units.

FIGURE 3

**Demultiplexing/remultiplexing routes for constructing
sub-STM-1 multiplex signals for FSS transmission**
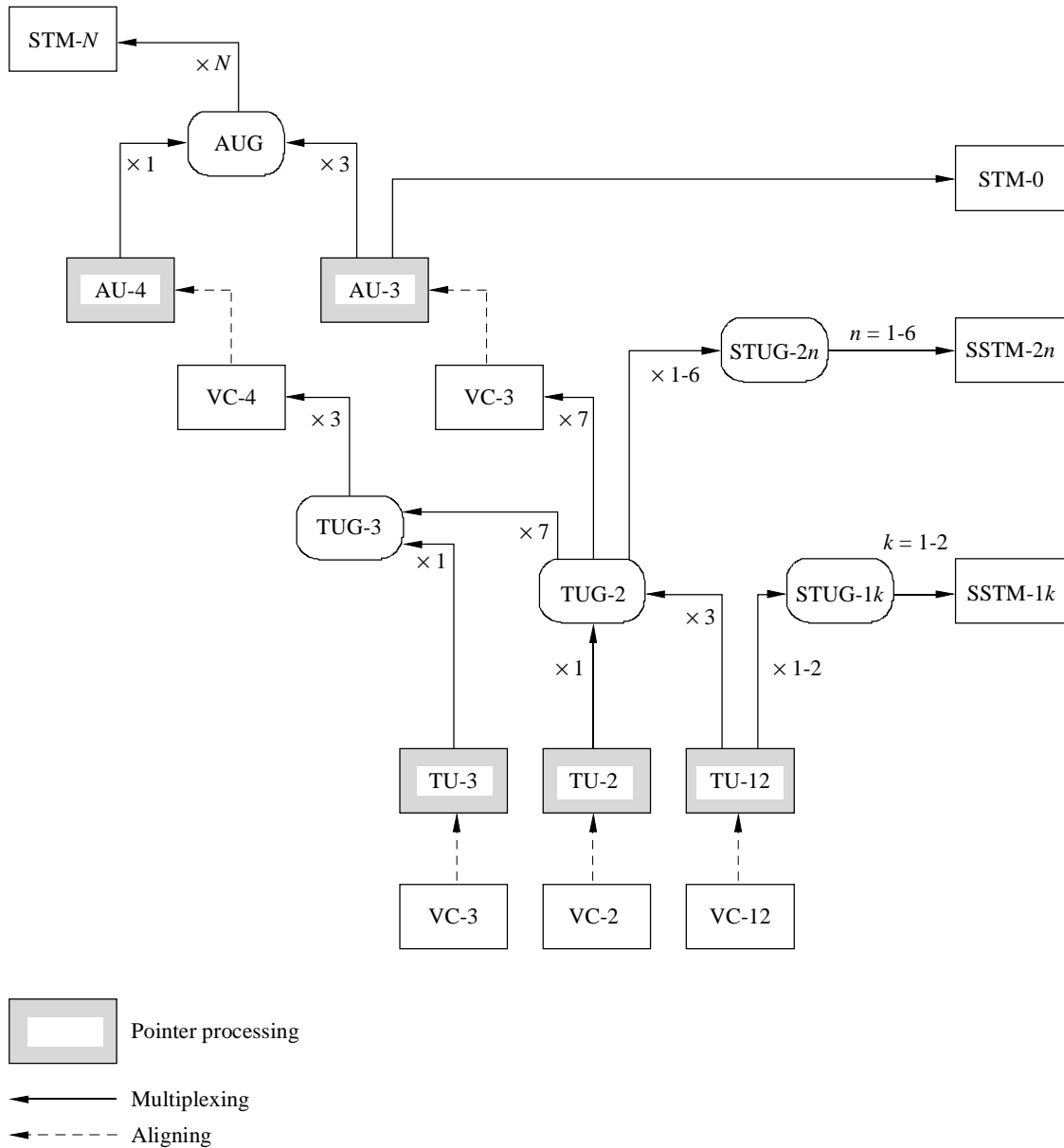
Note 1 - The need for a maximum value of n in STUG-2n is for further study.

Note 2 - Possible conversion routes: STM/-N/AUG/AU-4/VC-4/TUG-3/TUG-2/TU-12/STUG-1k/SSTM-1k

STM/-N/AUG/AU-4/VC-4/TUG-3/TUG-2/STUG-2n/SSTM-2n

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

STM/-N/AUG/AU-3/STM-0.   1149-03

2.2   SDH layered network modelling

ITU-T Recommendation G.805 defines the concept of a layered model of the transport network. Its use by all SDH network participants (designers, operators, equipment vendor) is essential for compatibility in design, operation and management.

ITU-T Recommendation G.805 defines two groups of network layers in the transport network, path layer and section layer. The SDH basic frame structure in Fig. 2 corresponds to the organization of the network in logical layers:

a) the path layer, consisting of: – the lower-order VC (LOVC) layer
                                                – the higher-order VC (HOVC) layer

b) the section layer, consisting of: – the multiplex section (MS) layer
                                                – the regenerator section (RS) layer

The RS layer is media dependent and the MS layer may be media dependent. The HOVC and LOVC are media independent and are components to construct, within their respective layers, G.805 subnetworks with a wide variety of topologies.

The G.805 layered network modelling is used, with suitable modifications, in the description of the three FSS-SDH network scenarios in § 4.

3   Applications of FSS in SDH transport networks

3.1   Service aspects

FSS systems in any of the three scenarios make up a part of the SDH transport network, thus contributing to the provision of efficient transmission network services to the SDH network users.

3.2   Network management aspects

3.2.1   General

Incorporation of SDH multiplex equipment functions as part of the satellite system synchronous baseband equipment facilitate commonality, accessibility, uniformity and integration in the overall SDH network management, and thus of the enhanced management functionality and of management automation.

3.2.2   SDH equipment and management functional blocks

The description methodology of ITU-T Recommendations G.782, G.783 and G.784 "Functional Reference Model" is used. The satellite system SDH equipment is defined as a collection of functional blocks, logically partitioned to facilitate the description of functions, operation and management of the whole system. It does not impose nor imply any physical partitioning of implementations along the block boundaries. A generic functional block diagram of a satellite system SDH multiplex equipment including its management and timing functional blocks is given in Figs. 4a and 4b (derived from Fig. 2-1/G.783).

These figures include all functions required for the transport and management of user's traffic from one or more external ingress interfaces to one or more external egress interfaces.

Decomposition of FSS-SDH synchronous baseband equipment into selected functional blocks for the three network scenarios is described in § 5.1, 5.2 and 5.3.

3.3   FSS system operational aspects

3.3.1   Multiplexing flexibility and efficiency

Use of the flexible SDH multiplexing techniques in the satellite system facilitates the realization of efficient multidestination operation.

3.3.2   Timing

Satellite motion buffers to remove Doppler timing variations are in practice combined with plesiochronous buffers. Table 1 gives the required satellite motion (Doppler) buffer sizes as a function of satellite orbit inclination. Complete removal of Doppler timing variations is only possible when these can be separated from clock drifts (the received satellite signals show the combined phase effects). This is possible when real-time satellite position information is available at the receive and possibly transmit ends (e.g., in SS-TDMA systems).

FIGURE 4a

General functional block diagram of SDH based SBE
(transport functional blocks)

S35 — **SSPI** Satellite synchronous physical interface — T2	S35 — **SSPI** Satellite synchronous physical interface — T2
S34 — **SST** Satellite section termination — T0, U32	S34 — **SST** Satellite section termination — T0, U32
S33 — **HSSA-*n*** Higher order satellite section adaptation — T2, T0	S30 — **LSSA-*m*** Lower order satellite section adaptation — T2, T0

LPC-*m*
S8 — Lower order path connection — T0

S17 — **LSUM-*m*** Lower order supervisory — T0 unequipped monitor

LSUG-*m* Lower order supervisory unequipped generator — S19, T0

S21 — **LPOM-*m*** Lower order path — T0 overhead monitor

S7 — **HPA-*m/n*** Higher order path adaptation — T0, U5

S6 — **HPT-*n*** Higher order path termination — T0, U3

S5 — **HPC-*n*** Higher order path connection — T0

S16 — **HSUM-*n*** Higher order supervisory — T0 unequipped monitor

HSUG-*n* Higher order supervisory unequipped generator — S18, T0

S20 — **HPOM-*n*** Higher order path — T0 overhead monitor

S4 — **MSA** Multiplex section adaptation — T0

S14 — **MSP** Multiplex section protection — T0

S3 —, P — **MST** Multiplex section termination — T0, Y, U2

S2 —, N — **RST** Regenerator section termination — T0, U1
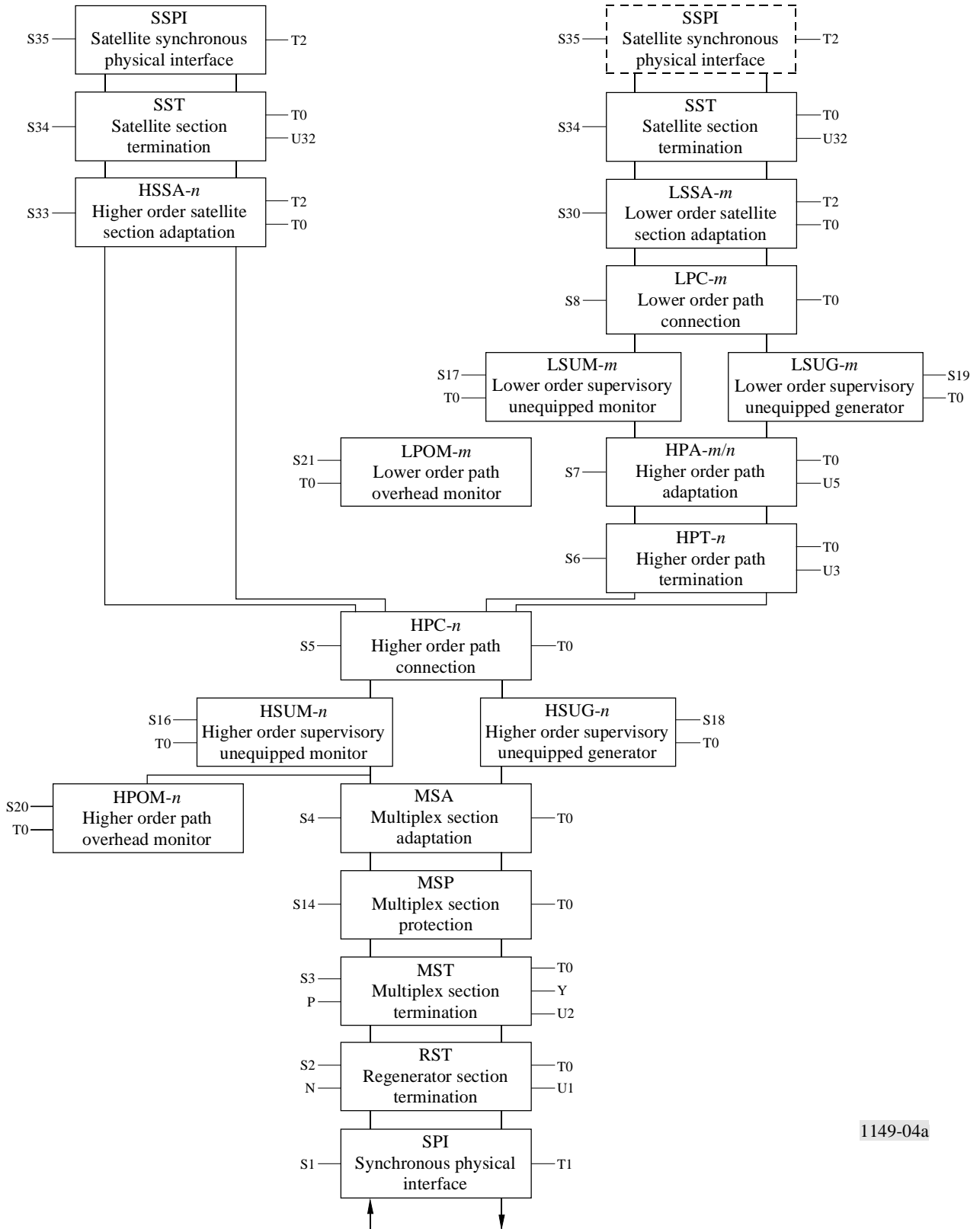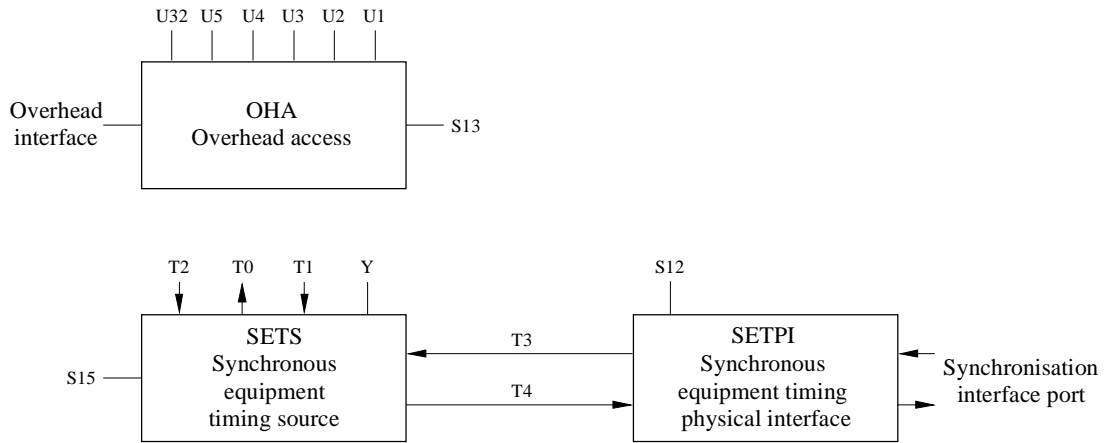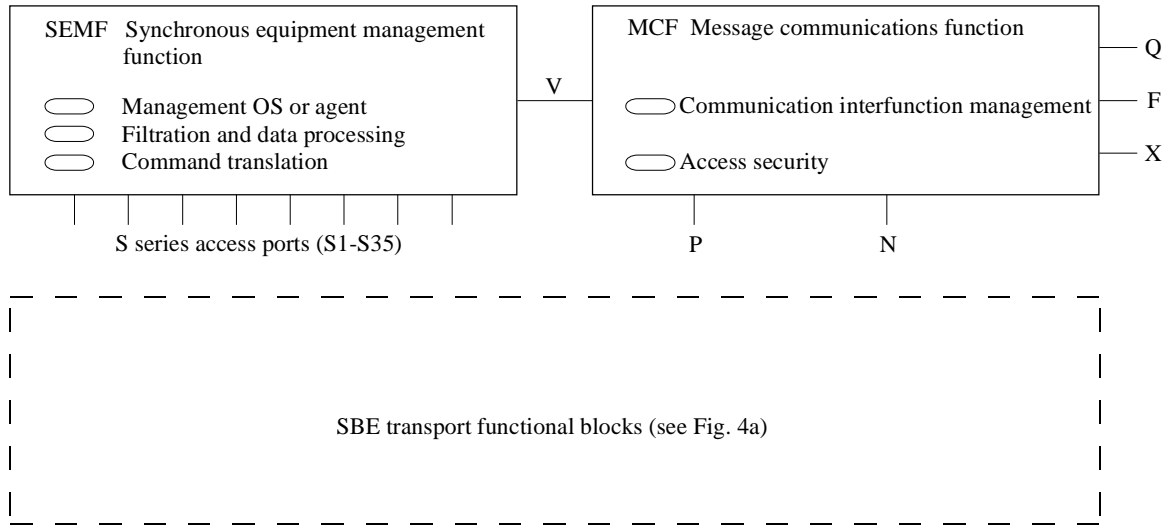
S1 — **SPI** Synchronous physical interface — T1

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FIGURE 4b

**General functional block diagram of SDH based SBE
(timing and management functional blocks)**

TABLE 1

Doppler buffer size as a function of satellite orbit inclination

Inclination (degrees)	Maximum Doppler (relative frequency)	Minimum buffer size (ms)
0.1	$\pm 1.8 \times 10^{-8}$	1.2
0.5	$\pm 4.0 \times 10^{-8}$	2.2
1.0	$\pm 6.7 \times 10^{-8}$	3.6
1.5	$\pm 9.4 \times 10^{-8}$	5.2
2.0	$\pm 1.2 \times 10^{-7}$	6.6
2.5	$\pm 1.5 \times 10^{-7}$	8.2
3.0	$\pm 1.6 \times 10^{-7}$	9.6

The SDH AU and TU pointer processing guarantees payload data integrity during controlled timing slips (plesiochronous interfacing) between two digital networks with different primary clock references. The benefit of SDH payload data integrity during controlled slips is gained by integrating the SDH pointer processing with Doppler processing, as described in § 5.1, 5.2 and 5.3.

3.3.3   Satellite connection availability, automatic protection switching

Subject to economic trade-off, availability of satellite systems which are subject to propagation degradation and outages could be maintained above a certain design limit, using the SDH network self-healing feature within the satellite system, i.e., SDH automatic protection mechanisms at path or section layers or both. This is for further study.

4   FSS-SDH network scenarios, modelling and description

4.1   Digital sections (scenario 1)

4.1.1   Description

The SDH transport network perspective of this scenario is given in Fig. 1 of ITU-T Recommendation G.861.

As a point-to-point regenerator section operating at STM-1 (155.52 Mbit/s), access to the standard RSOH functions, such as BIP-8 error monitoring, DCC and voice order wires can be gained at the system SBE. Transparency to MSOH K1/K2 bytes permits multimedia automatic network level protection of mixed-media multiplex sections. The MST and MSP functions are at the extreme (terrestrial) ends of the interoffice MSs. Reference point A (Fig. 1) is an open interface (G.957 optical and G.703 electrical) at STM-1 rate, with the SBE acting as an SDH (satellite) regenerator terminals (SRTs).

The "ITU-T Recommendation G.861 radio and satellite SDH integration guidelines" also allow radio and satellite synchronous digital sections operating at 51.84 Mbit/s, as well as within existing 140 Mbit/s PDH facilities through a G.732 type interworking multiplexer. The SDH signal conversion from STM-1 to reduced bit rate synchronous structures is a line terminal (LT) functionality. Multipoint/multidestination satellite operation is not part of this scenario.

4.1.2   Layered network model

The G.805 layered network model of the FSS-SDH digital section is given in Fig. 5. The model presentation is adapted to reflect transparency of the system to one or more layers of the interconnected terrestrial networks. The RS is shown terminated by the satellite transmission system, and the MS and all LOVC and HOVC signals are transported transparently.

4.2   Wide-area single-rate cross-connect (scenario 2)

4.2.1   Description

This scenario employs the wide-area visibility of the satellite to create a cross-connect function which operates internally at a single bit rate of 51.84 Mbit/s. The SDH transport network perspective of this scenario is given in Fig. 2 of ITU-T Recommendation G.861.

The cross-connect and other SDH equipment functions are replicated and distributed over various earth station locations SBEs, and system interfacing to the terrestrial SDH networks is through standard NNIs.

The SBE permits efficient byte-oriented (asymmetric) add/drop functions of payload traffic (VC-12, TUG-2) to/from SDH multiplex signals to support multidestination satellite operation. The internal cross-connect synchronous signal transport at STM-0 (51.84 Mbit/s) supports "medium" satellite routes, and implements both point-to-point and point-to-multipoint S-IOS. In multidestination operation, each SBE handles its SDH payload traffic within a single transmit and several receive unidirectional S-IOSs to/from multiple correspondents. The SBE is based on 51.84 Mbit/s synchronous multiplex equipment, modified to allow asymmetrical working across the satellite equipment interfaces (SEI at reference point B in Fig. 1). Across the terrestrial NNI (reference point A), the SBE as a SLT can perform normal RST, MST and MS APS functions. Transported client signals are VC-12, VC-2 and VC-3 point-to-point path layer connections. Standard path status monitoring, end-to-end tracing and BIP-2/8 error monitoring in the POH are carried transparently through the cross-connect.

FIGURE 5

Layered model of point-to-point FSS-SDH digital section at STM-1
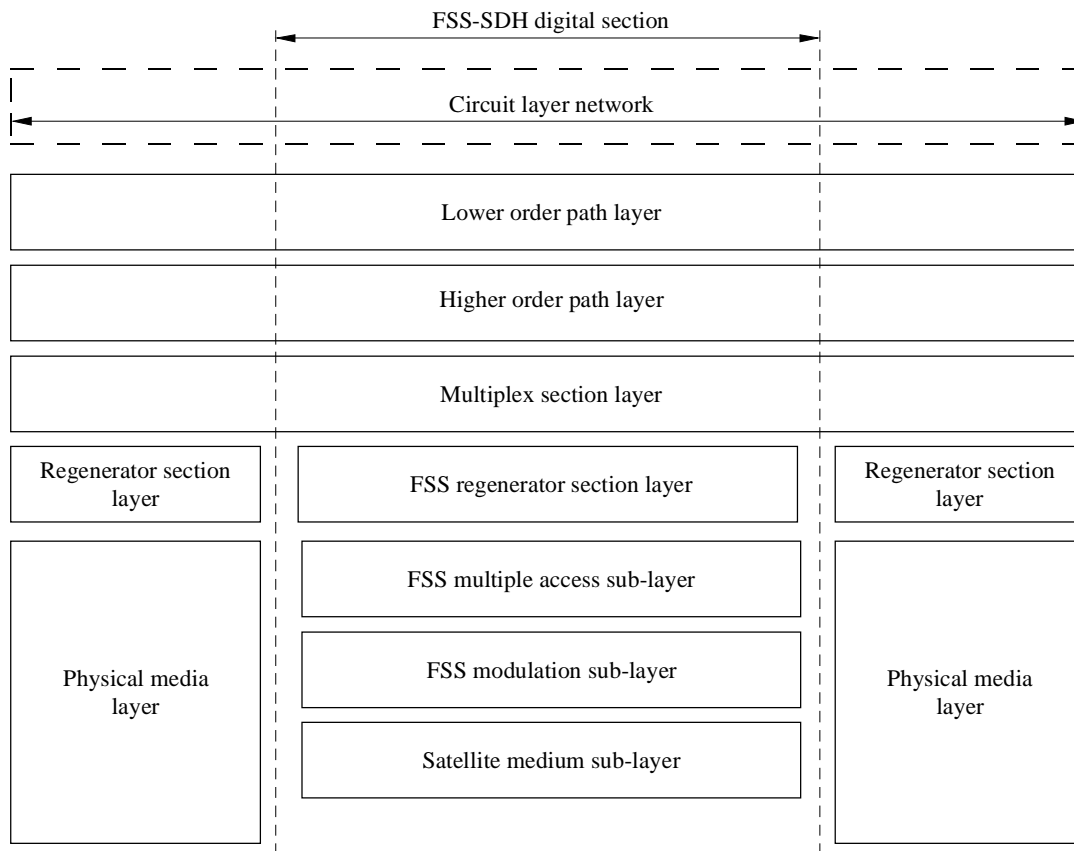
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4.2.2 Layered network model

The G.805 layered network model of the wide-area cross-connect is given in Fig. 6. The model presentation is adapted to reflect transparency of the system to one or more layers of the interconnected terrestrial networks. A MDSS layer is introduced to aid the modelling of system internal multi-destination connections at STM-0. The MDSS layer extends strictly from the bottom satellite medium sublayer, to the (sub)-layer boundary with the client layer network.

MD trails in the MDSS layer provide link connections with simple point-to-point topology in the path layer networks. MD trails also lend themselves as servers of (future) complex point-to-multipoint connection topologies in the path layer networks.

SDH signal handling within the MDSS layer is characterized by:

– SDH signal element groupings to one common satellite route size (STM-0);

– asymmetries in number of directional satellite sections between communicating earth stations;

– restricted visibility from the externally terminated SDH network server trails.

Satellite networks formed within the MDSS layer are restricted to the FSS-SDH system, but provides transparency to G.805 type subnetworks in the path layer networks.

The highest server network sublayer with externally terminated trails is the VC-4 HOVC sublayer. RS, MS and VC-4 trails are terminated. Within the MDSS layer, VC-3 payload signals (and possibly lower order VCs) are unbundled, regrouped, and re-multiplexed into satellite section frames for multidestinational IOS transmission at STM-0 (51.84 Mbit/s) rate.

FIGURE 6

Layered model of scenario 2 with MDSS
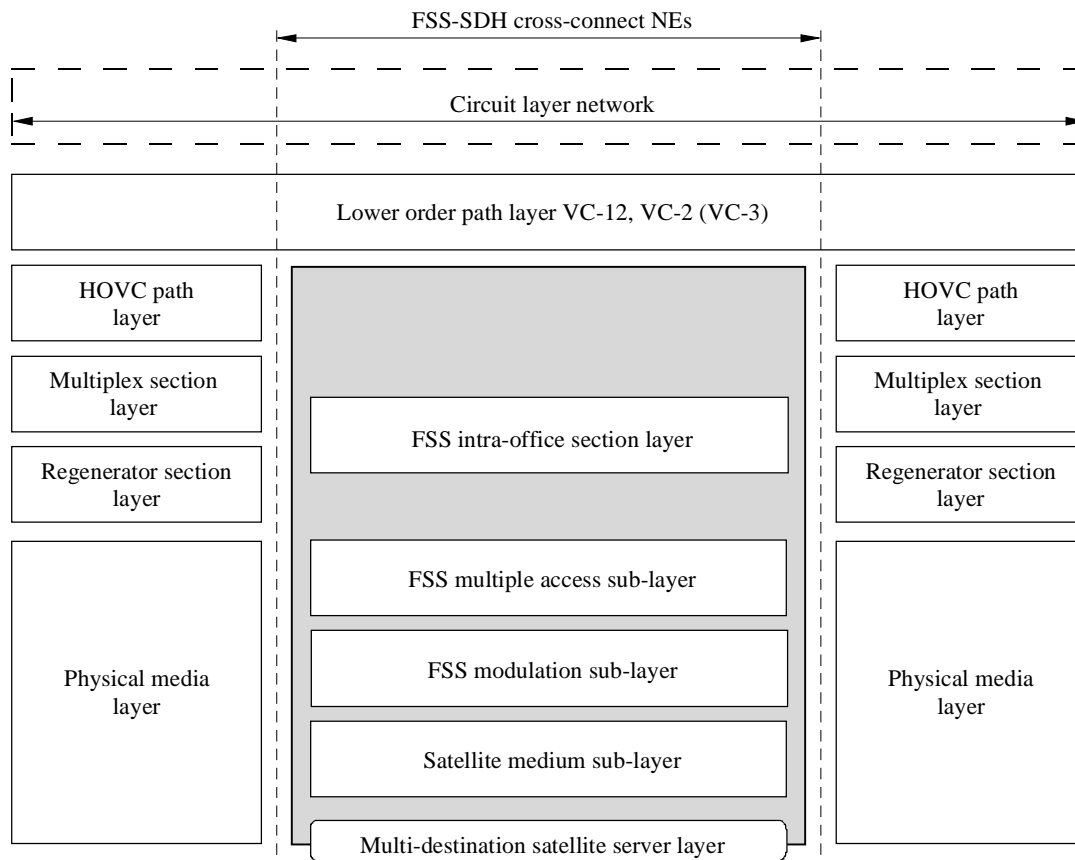
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4.3 Wide-area multi-rate cross-connect (scenario 3)

4.3.1 Description

The SDH transport network perspective of this scenario is given in Fig. 2 of ITU-T Recommendation G.861.

This scenario has similar characteristics to scenario 2, i.e., wide-area replication and distribution of cross-connect and other SDH equipment functions over the systems' SBEs. Reference points A (Fig. 1) are standard NNIs, across which the SBE as a SLT performs normal RST, MST and MS APS functions. Internally across reference point B, the SBE supports asymmetrical VC-12, TUG-2 add/drop connection functions and S-IOS connections.

The cross-connect internal synchronous transport is over both point-to-point and point-to-multipoint S-IOSs, operating at a range of sub-STM-0 rates (carriage capability 1, 2, 3, 6, 9, 12, 15, 18 x VC-12s) defined in § 2.1.2 for "thin-route" satellite traffic. In multidestination operation, each SBE handles its SDH payload traffic within a single transmit and several receive unidirectional S-IOSs to/from multiple correspondents.

The SBE is a new generation of synchronous multiplex equipment developed for satellite systems. The SEIs (at reference point B in Fig. 1) are internal interfaces not defined in ITU-T Recommendations. Section 5.3 defines the SEI multiplex format and structure, and reduced S-IOS OH functionalities and allocation.

Transported client signals are VC-12 point-to-point path layer connections. Standard path status monitoring, end-to-end tracing, BIP-2 error monitoring in the POH are carried transparently through the cross-connect.

4.3.2 Layered network model

The G.805 layered network model of the wide-area cross-connect is given in Fig. 7. The model presentation is adapted to reflect transparency of the system to one or more layers of the interconnected terrestrial networks and to accommodate the internal MDSS layer.

FIGURE 7

Network layered model of scenario 3 with MDSS
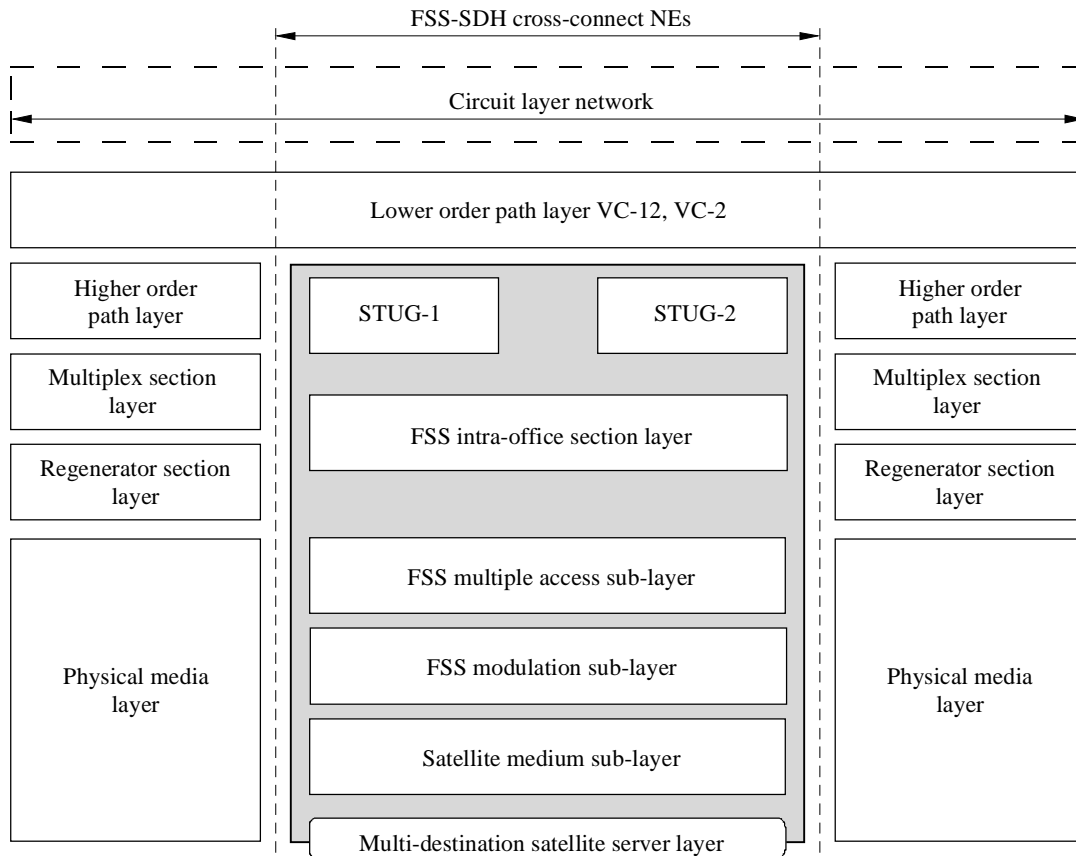
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SDH signal handling within the MDSS layer is characterized by:

– SDH signal element groupings optimized to satellite traffic route sizes (STUG payloads);

– asymmetries in number and sizes of directional satellite sections between communicating earth stations;

– restricted visibility from the externally terminated SDH network server trails.

Satellite networks formed within the MDSS layer are restricted to the FSS-SDH system, but provides transparency to G.805 type subnetworks in the path layer networks.

In Fig. 7, the highest server network sublayer, at which external trails are terminated is the HOVC sublayer. RS, MS, VC-4 and VC-3 trails are terminated. Within the MDSS layer their LOVC payload signals are unbundled, regrouped, and re-multiplexed into satellite section frames for multidestinational IOS transmission at lower rates, defined in § 5.3.

# 5   FSS-SDH synchronous baseband equipment

5.1   SBE for SDH digital section (scenario 1)

The SBE generally consists of SDH physical interface termination, regenerator and multiplex section termination and HSSA. MS protection switching capability for the terrestrial links accessing the SBE is not a requirement in this scenario. HOVC and LOVC path tandem connection monitoring using the Z5 byte (VC-3, VC-4), and the Z6 byte (VC-2) is an optional capability.

5.1.1   Digital section at 155.52 Mbit/s (STM-1)

In terms of equipment functional blocks defined in ITU Recommendations G.782 and G.783, the minimum SBE functional configuration shall be as given in Fig. 8, which shows a select set of functional blocks of the generic block diagram (see Fig. 4a). As a regenerator section as part of an MS, the satellite system in principle does not terminate MS (MST is depicted as optional). RST function shall be used to locate and position AU pointer bytes in the frame to facilitate AU pointer processing in the HSSA for timing purposes (see § 5.1.3).

FIGURE 8

**SBE functional blocks for scenario 1 (STM-1)**
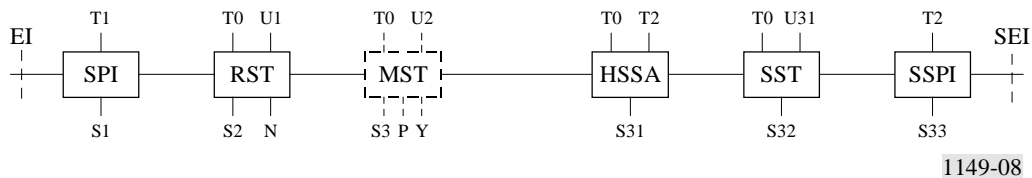
A modem function operating at the STM-1 rate of 155.52 Mbit/s is required for the satellite transmission equipment. No elastic Doppler buffer function is required in the modem equipment (see § 5.1.4).

5.1.2   PDH embedded transmission of SDH signals

Satellite systems with PDH transmission capabilities at 34, 45 and 140 Mbit/s rates can be used to transport SDH signals embedded in PDH structures according to ITU-T Recommendation G.832. In terms of equipment functional blocks, the G.832 based SBE minimum configuration shall be as given in Fig. 9, which shows a select set of functional blocks of the generic block diagram (see Fig. 4a).

FIGURE 9

SBE functional blocks for scenario 1 (G.832 conversion)
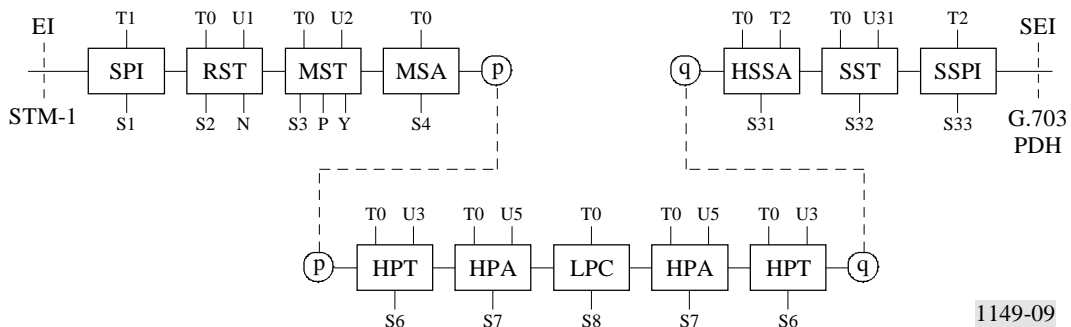
Elastic (Doppler) buffer operation is preferably part of the HSSA (see § 5.1.4), and its inclusion in standard PDH satellite modem equipment is for further study.

**5.1.3   Satellite digital section at 51.84 Mbit/s (STM-0)**

ITU-T Recommendation G.707 defines the frame structure of a 51.84 Mbit/s synchronous signal for use in radio and satellite systems. The SBE functional blocks for the STM-N/STM-0 converter (an LT functionality) are generally similar to the G.832 SBE shown in Fig. 9, including the HSSA functionality described in § 5.1.4.

A modem operating at the STM-0 information rate of 51.84 Mbit/s, plus possible satellite function complementary overhead (SFCOH), is required. Elastic Doppler buffer operation is part of the HSSA, and thus is not required in the modem function (see § 5.1.4).

5.1.4   AU pointer processing and Doppler buffers

Data (SDH payload) loss due to plesiochronous clock differences between interconnected synchronous digital networks is avoided by the SDH justification mechanism controlled by the AU pointer processing. Motion buffers for the removal/reduction of phase variations due to satellite Doppler shall be integrated with the AU pointer regeneration in the SBE (receive side) as shown in Fig. 10 for the STM-1 case.

FIGURE 10

SBE integrated pointer and Doppler processing (STM-1)
(HSSA receive side)
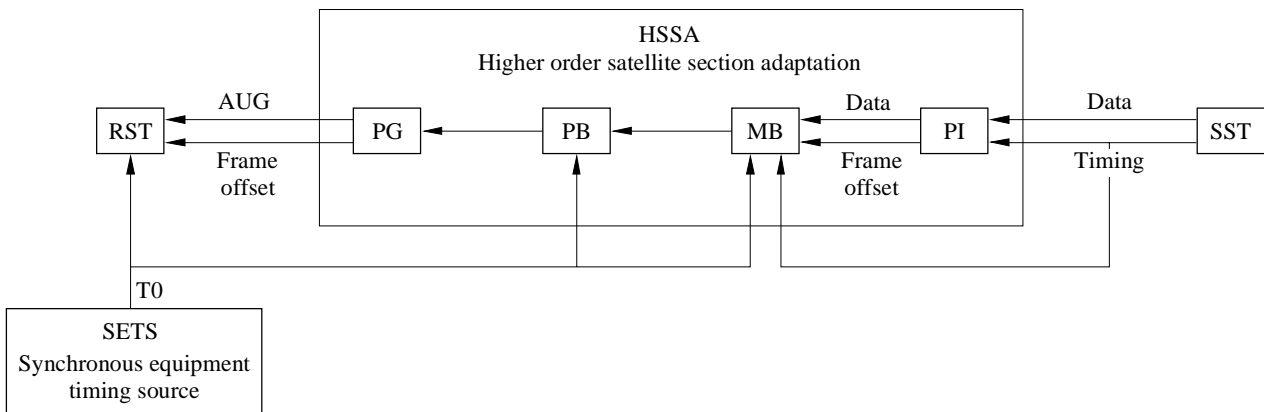
MB: motion buffer
PB: pointer buffer
PG: pointer generator
PI: pointer interpreter

1149-10

Although the figure shows the pointer buffer (PB) and motion buffer (MB) as functionally distinct entities, they can be more efficiently implemented by a common physical element.

The basic algorithm of AU pointer processing is given in ITU-T Recommendation G.783.

SBEs based on ITU-T Recommendation G.832 may not be equipped with satellite Doppler compensation. In this case, the G.703 SEI shall include a dedicated interface to extend timing from the AU pointer processing in the SBE for Doppler buffer read-out in the satellite transmission equipment (modem). This is for further study.

5.1.5   Alarm conditions and consequent actions

FIGURE 11

Scenario 1 OAM model
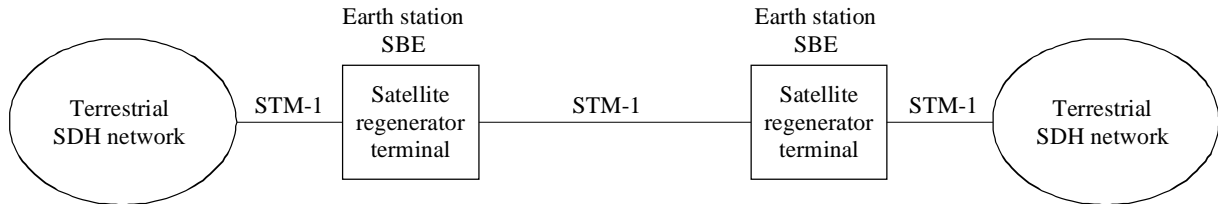
1149-11

The SBE shall detect loss of signal (LOS) or loss of frame (LOF) on the satellite section and indicate multiplex section alarm indication signal (MS AIS) to the downstream multiplexer of the terrestrial SDH network. In response to the MS AIS, the downstream multiplexer will send a multiplex section remote defect indication (MS RDI) signal in the backward direction to inform the upstream multiplexer of the far-end terrestrial SDH network that it has received a section AIS from the connecting satellite network.

The fault conditions and the appropriate consequent actions for scenario 1 are summarized in Table 2. LOS, LOF, AU-LOP, MS AIS and AU-AIS are defined in ITU-T Recommendation G.783.

TABLE 2

Fault conditions and consequent actions taken by the SBE in scenario 1

Interface	Failure condition	Consequent actions taken by the SBE[1]			
		Signal generated towards local terrestrial network		Signal generated towards local SEMF	Signal generated towards remote SBE
		MS AIS	AU-AIS		MS AIS
Local terrestrial network interface	LOS/LOF			Yes	Yes
Satellite network interface	LOS/LOF	Yes		Yes	
	AU-LOP		Yes	Yes	

[1]   A "Yes" in a table entry signifies that the specified action shall be taken by the SBE as a consequence of the fault condition. A blank in a table entry signifies that the specified action shall not be taken by the SBE because either the fault condition is not visible to the SBE or no action is required from the SBE as a consequence of the fault condition.

The time interval between the detection of LOS/LOF and the transmission of section AIS, the duration of section AIS, and the time interval between the termination of LOS/LOF and the removal of section AIS are for further study.

5.2   SBE for wide-area single-rate cross-connect (scenario 2)

The SBE generally consists of SDH physical interface termination, RST and MST, HSSA, higher and lower order path connection functions (HPC and LPC). MS protection switching capability shall be provided on the terrestrial side of the SBE. HOVC and LOVC path tandem connection monitoring using the Z5 byte (VC-3, VC-4), and the Z6 byte (VC-2) is an optional capability.

The SBE shall extract HOVCs (VC-3s) and provide cross-connection of VC-3 signals under the control of network management. The SBE shall also terminate the higher order path overhead, and shall extract the lower order VC-12s from the tributary unit groups for some signals. The SBE will support cross-connection of the VC-12 signals under the control of network management. An example SBE asymmetric multidestination configuration with different destination traffic sizes is shown in Fig. 12. Multidestinational SBEs may have multiple transmit ports, which is an implementation matter.

FIGURE 12

SBE asymmetric MD configuration
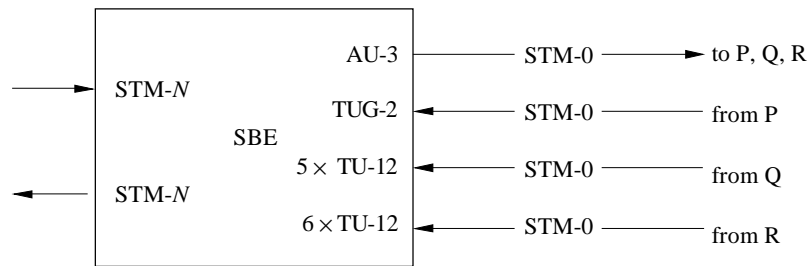
1149-12

Figure 13 shows the SBE internal functional blocks.

The satellite section physical interfaces at 51.84 Mbit/s is FFS. (An alternative is to use the SONET 51.84 Mbit/s physical and electrical interface characteristics contained in Bellcore standard TR-TSY-000253.)

The HSPA functionality shall be:

Multiplexing and demultiplexing of LOVCs (VC-12, VC-2) and possibly HOVC (VC-3) and asymmetry reconciliation.

The HSSA functionality shall be:

–   generation of AU pointers to form AU-3 signals according to ITU-T Recommendation G.707;

–   adaptation of the outgoing signal to 51.84 Mbit/s synchronous signal for transport over the S-IOS;

–   recovery of VC-3 signals and associated frame offset information from the received AU pointers;

–   buffering AU-3 signals to remove/reduce Doppler effects without data loss.

5.2.1   SSOH functions including multidestination for S-IOs

The SSOH is inserted/extracted at the HSPT satellite section termination point and it will support the following overhead functions for the S-IOS across the satellite subnetwork:

–   error monitoring;

–   remote error indication for multiple connections;

–   remote defect indication for multiple connections;

–   data communications channel (DCC) for multiple connections;

–   VOW channel for multiple connections and conference calls;

–   500 μs multiframe alignment.

FIGURE 13

SBE functional blocks for scenario 2

1149-13
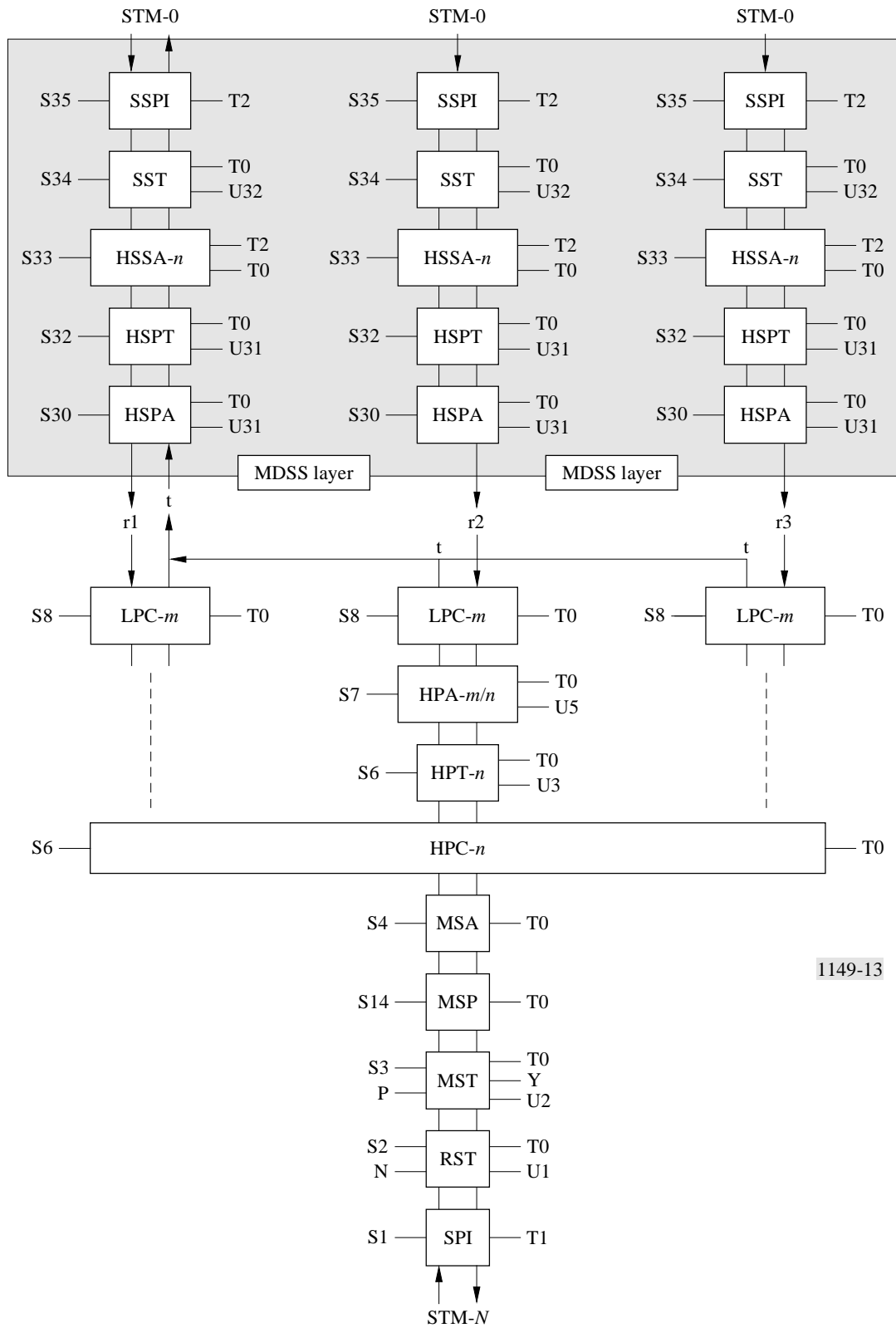
5.2.2 Section layer frame format and multiplex structure

The S-IOS frame structure of the STM-0 synchronous signal module is based on ITU-T Recommendation G.707.

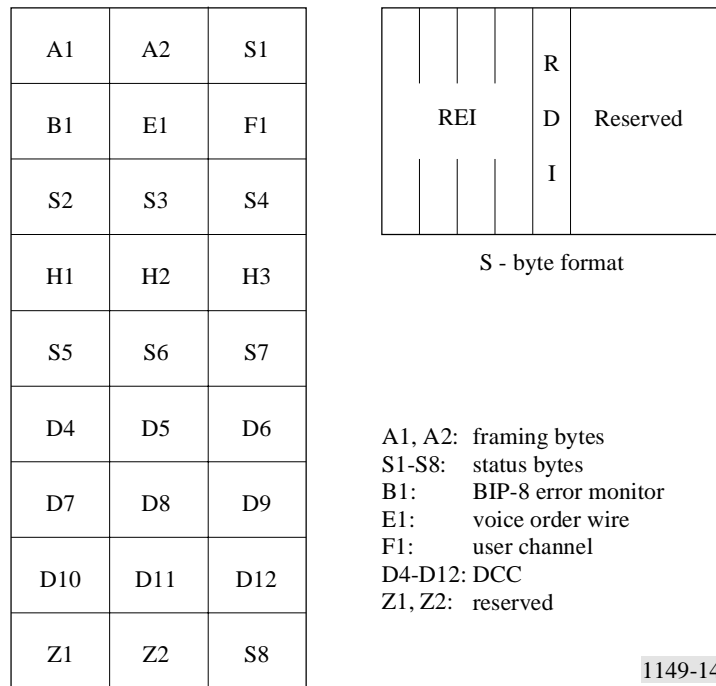Figure 14 shows STM-0 SOH byte re-allocation to accommodate addressing information for backward indications (RDI and REI) at the S-IOS layer for multidestination satellite operation.

FIGURE 14

STM-0 SOH byte reallocation for MD satellite operation

A1	A2	S1
B1	E1	F1
S2	S3	S4
H1	H2	H3
S5	S6	S7
D4	D5	D6
D7	D8	D9
D10	D11	D12
Z1	Z2	S8

REI	R D I	Reserved

S - byte format

A1, A2: framing bytes
S1-S8: status bytes
B1: BIP-8 error monitor
E1: voice order wire
F1: user channel
D4-D12: DCC
Z1, Z2: reserved

1149-14

Each status or S byte in the header is assigned to a particular correspondent via management interactions. This byte shall carry the far end receive failure indication as well as four bits for far end block error reporting. This will allow a station to report to its correspondent the number of interleaved parity bits that do not meet the parity check in the BIP-N block of each frame. All Reserved bits are set to zero when they are not allocated.

The DCC protocol and message multiplexing mechanism as well as the method of addressing the DCC to a specific destination are described in Annex 1 to this Recommendation.

5.2.3 AU pointer processing and Doppler buffers

The same requirements as in § 5.1.3 apply for each individual receive side HSSA.

5.2.4   Alarm conditions and consequent actions

FIGURE 15

Scenario 2 OAM model
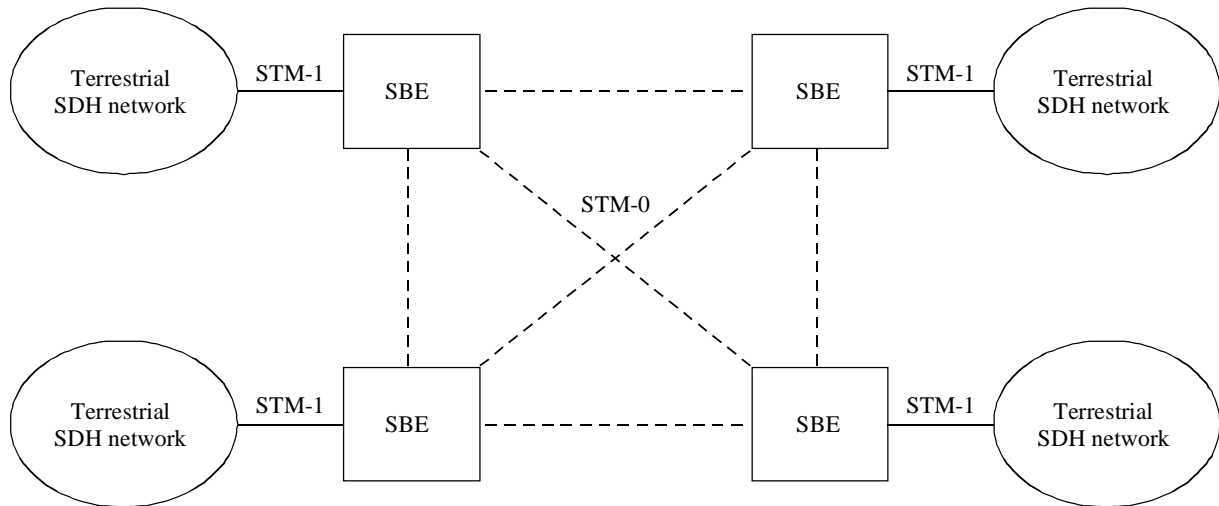
1149-15

The SBE shall detect LOS/LOF on the satellite section, and shall indicate to the downstream multiplexer of the terrestrial SDH network either the MS AIS, AU-AIS, or TU-AIS depending upon the number of AU/TUs affected; and shall indicate to the upstream SBE the satellite section S-IOS RDI signal.

The SBE shall detect loss of pointer (LOP) on the satellite section, and shall indicate to the downstream multiplexer of the terrestrial SDH network either the AU-AIS, or TU-AIS, and shall indicate to the upstream SBE either the HO-path or LO-path RDI signal depending upon the number of AU/TUs affected.

In multi-destination operation, the MS RDI signal is received by more than one upstream SBE; therefore, addressing of the upstream SBE, for which the MS RDI signal is intended, is necessary to ensure proper operation.

The fault conditions and consequent actions for scenario 2 are summarized in Table 3.

LOS, LOF, LOP and MS AIS are defined in ITU-T Recommendation G.783.

MS RDI, HO-RDI, LO-RDI, AU-AIS and TU-AIS are defined in ITU-T Recommendation G.707.

The time interval between the detection of LOS/LOF/LOP and the transmission of AIS and RDI signal, the duration of AIS and RDI signal, and the time interval between the termination of LOS/LOF/LOP and the removal of AIS and RDI signal are for further study.

5.3   SBE for wide-area multi-rate cross-connect (scenario 3)

The SBE generally consists of SDH physical interface termination, RST and MST, HSSA, higher order path termination and lower order path connection functions. MS protection switching capability shall be provided on the terrestrial side of the SBE.

HOVC and LOVC path tandem connection monitoring using the Z5 byte (VC-3, VC-4), and the Z6 byte (VC-2) is an optional capability.

TABLE 3

Fault conditions and consequent actions taken by the SBE in scenario 2

| Interface | Failure condition | Consequent actions taken by the SBE[1] | | | | | | | | | | | | |
| | | Signal generated towards local terrestrial network | | | | | | Signal generated towards local SEMF | Signal generated towards remote SBE | | | | | |
		MS AIS	MS RDI	AU-AIS	HO-RDI	TU-AIS	LO-RDI		S-IOS AIS	S-IOS RDI	AU-AIS	HO-RDI	TU-AIS	LO-RDI
Local terrestrial network interface	LOS/LOF		Yes					Yes	Yes					
	MS AIS		Yes					Yes						
	MS RDI							Yes						
	AU-LOP				Yes			Yes			Yes		Yes	
	AU-AIS				Yes								Yes	
	HO-RDI													
	TU-LOP						Yes	Yes					Yes	
	TU-AIS												Yes	
	LO-RDI													
Satellite network interface	LOS/LOF	Yes[2]		Yes[3]		Yes[4]		Yes		Yes[5]				
	S-IOS AIS							Yes		Yes[5]				
	S-IOS RDI							Yes						
	AU-LOP			Yes[3]		Yes[4]		Yes				Yes		
	AU-AIS													
	HO-RDI													
	TU-LOP					Yes		Yes						Yes
	TU-AIS													
	LO-RDI													

[1] A "Yes" in a table entry signifies that the specified action shall be taken by the SBE as a consequence of the fault condition. A blank in a table entry signifies that the specified action shall not b
taken by the SBE because either the fault condition is not visible to the SBE or no action is required from the SBE as a consequence of the fault condition.

[2] In multi-destination, applied when LOS/LOF occurs on all received signals.

[3] In multi-destination, applied on relevant AU signals.

[4] In multi-destination, applied on relevant TU signals.

[5] Includes addressing of the upstream SBE for which the MS RDI is intended (in multi-destination operation).

The SBE shall terminate the higher order path overhead, and shall extract the lower order VC-12s from the tributary unit groups. The SBE will support cross-connection of the VC-12 signals under the control of network management. An example SBE asymmetric multidestination configuration with different destination traffic sizes is shown in Fig. 16. Multi-destinational SBEs may have multiple transmit ports, which is an implementation matter.

FIGURE 16

SBE asymmetric MD configuration
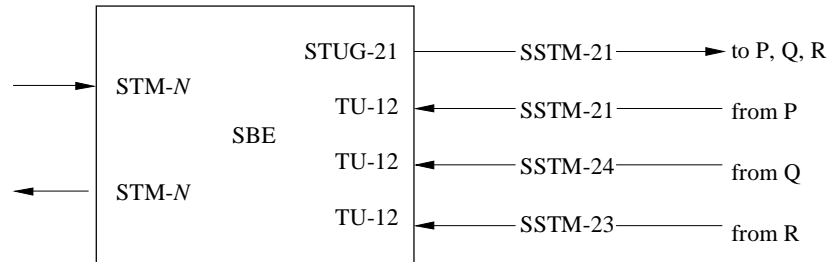
1149-16

Figure 17 shows the SBE functional blocks. Multiplexing and demultiplexing of LOVCs to/from STUGs of different sizes, and MD asymmetry reconciliation are accomplished by the LSSAs.

SSPIs are either system dependent or may appear as open interfaces, i.e. the SBE and satellite transmission equipment may be integrated. In such cases, the SST interfaces directly with the multiple access system through ISIs.

The LSSA functions shall be:

–   generate TU pointers to form TU-12 signals (identical to the TU pointer processing in the HPA function defined in ITU-T Recommendation G.783), and multiplex TUs into STUG;

–   adapt the outgoing tributary unit group (STUG) signal to the SSTM-1/2n synchronous signals for transport over the S-IOS across the satellite network;

–   recover VC-12 signals and their associated frame offset information by interpreting TU pointers from individual received STUG tributaries;

–   buffer received TU-12 signals to remove effects of satellite Doppler without data loss.

5.3.1   SSOH functions including multidestination for satellite intra-office sections

The SSOH will support the following overhead functions for the S-IOS across the satellite system:

–   error monitoring,

–   far end block error reporting for multiple connections,

–   far end receive failure reporting for multiple connections,

–   DCC for multiple connections,

–   source trail tracing,

–   voice order wire (VOW) for multiple connections and conference calls,

–   VC-12 payload type,

–   500 μs multiframe alignment.

FIGURE 17

SBE functional blocks for scenario 3

1149-17
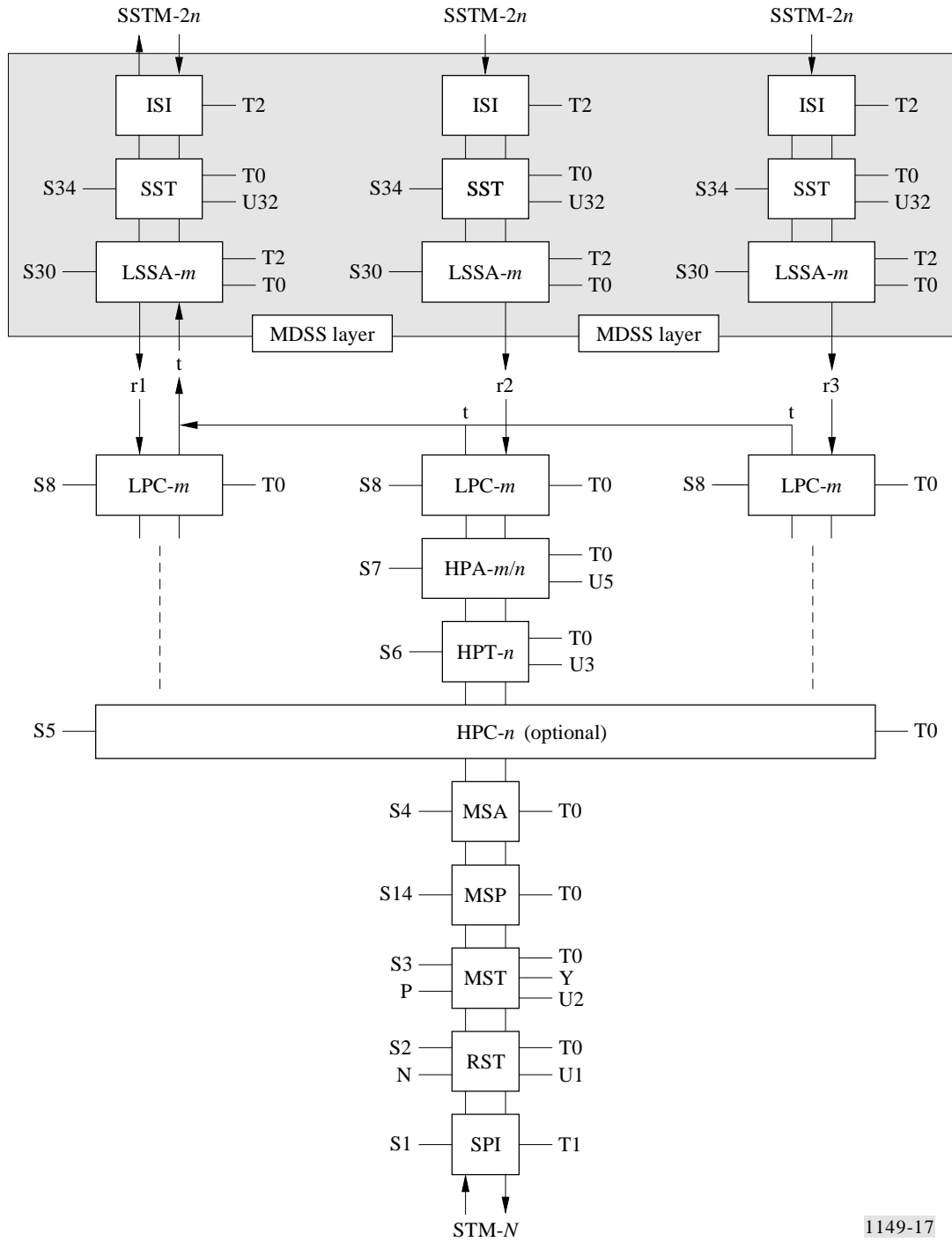
5.3.2   Satellite tributary unit groups 1/2 multiplex structures

STUG-1n (n = 1, 2) signals are made up of one or two TU-12 signals respectively. A STUG-11 is equivalent to a TU-12 and a STUG-12 is made up of two, byte multiplexed, TU-12 signals as shown in Fig. 18.

FIGURE 18

STUG-12 format

1149-18
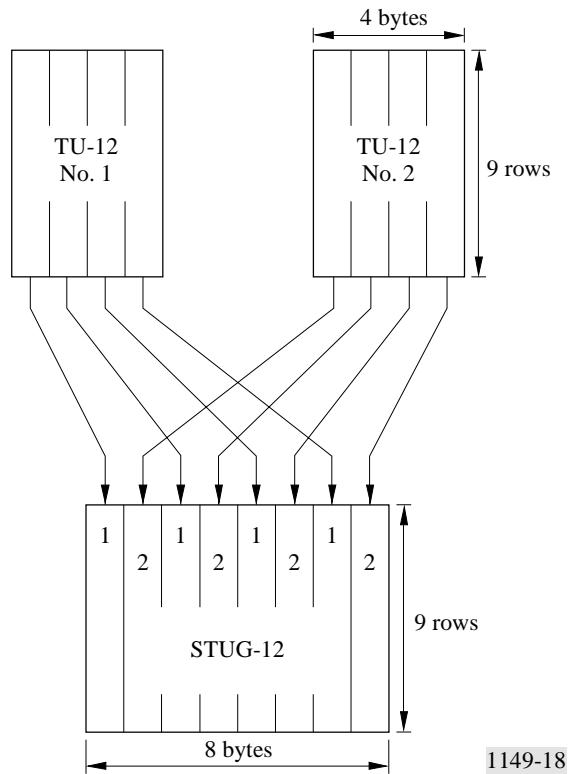
STUG-2n (n = 1-6) signals are made up from one to six TUG-2 signals, byte multiplexed.

Byte multiplexing of TU-12s to form TUG-2s and byte multiplexing of TUG-2s to form an STUG-2n, is shown in Fig. 19.

FIGURE 19

STUG-2*n* format

1149-19
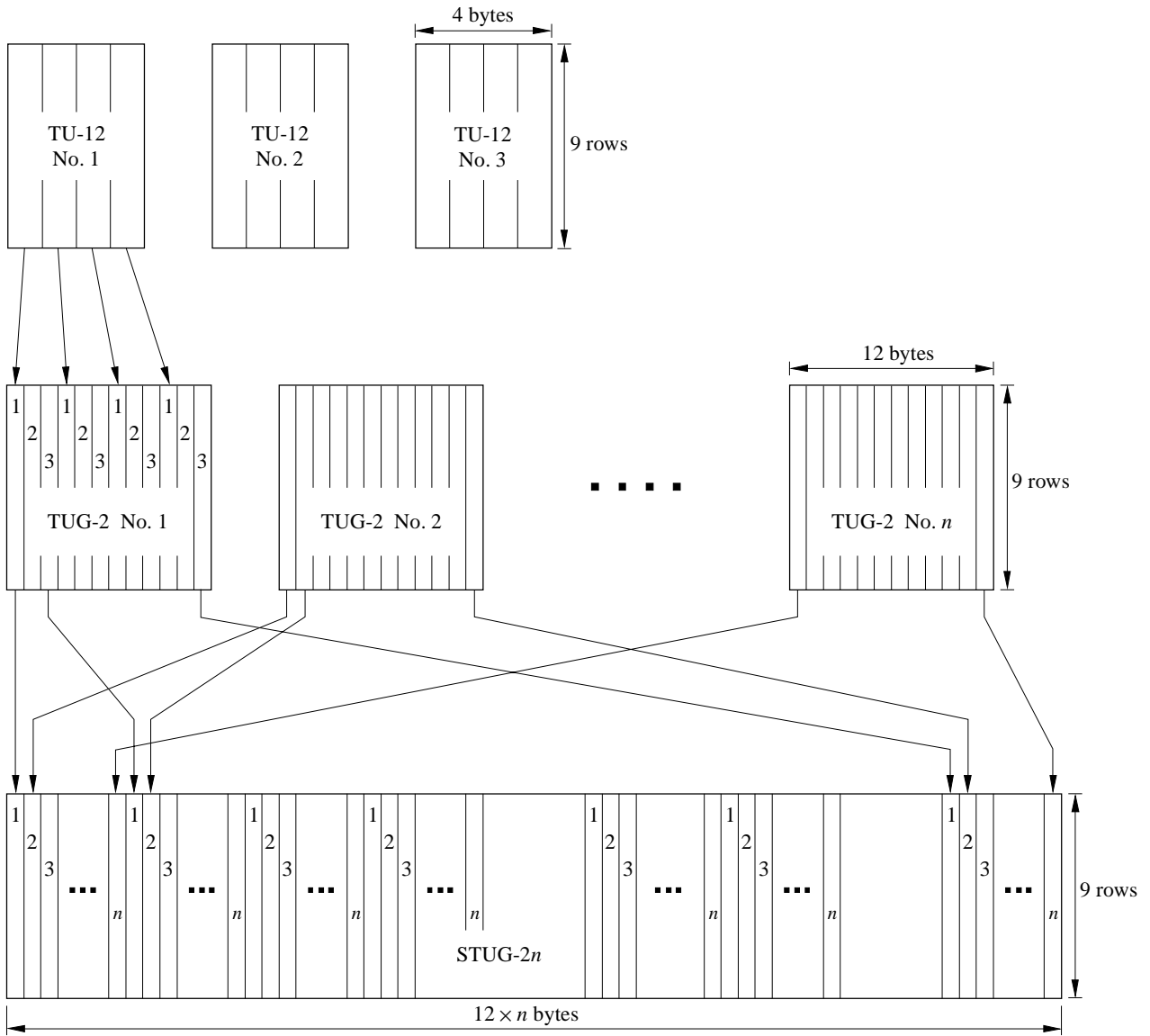
5.3.3   Satellite section layer frame structures

FIGURE 20

SSTM-1 structure
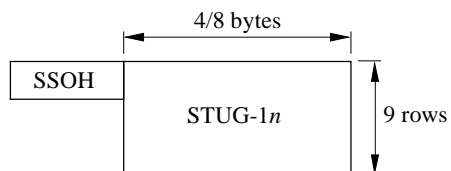
FIGURE 21

SSTM-2 structure

1149-20-21

5.3.4   SSOH allocation

FIGURE 22

SSOH structure

1149-22

The SSOH contains 2 bytes transmitted every 125 μs. The allocation of bits within the SSOH is as follows:

Frame alignment word *FAW (32 bits, 4 bits per frame)*

The FAW synchronizes the receiving SST to the start of the SSTM frame. Particular 4 bits patterns of the FAW are used to indicate the start of a 1 ms multiframe (CC frame), used for the control channel and source trail trace, and the start of the 500 μs multiframe pointing to the first V1 byte of the STUG multiplex payload.

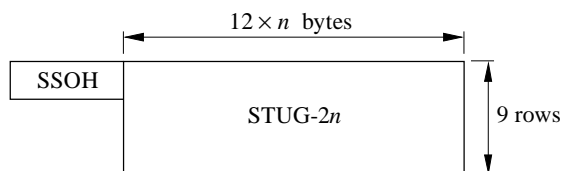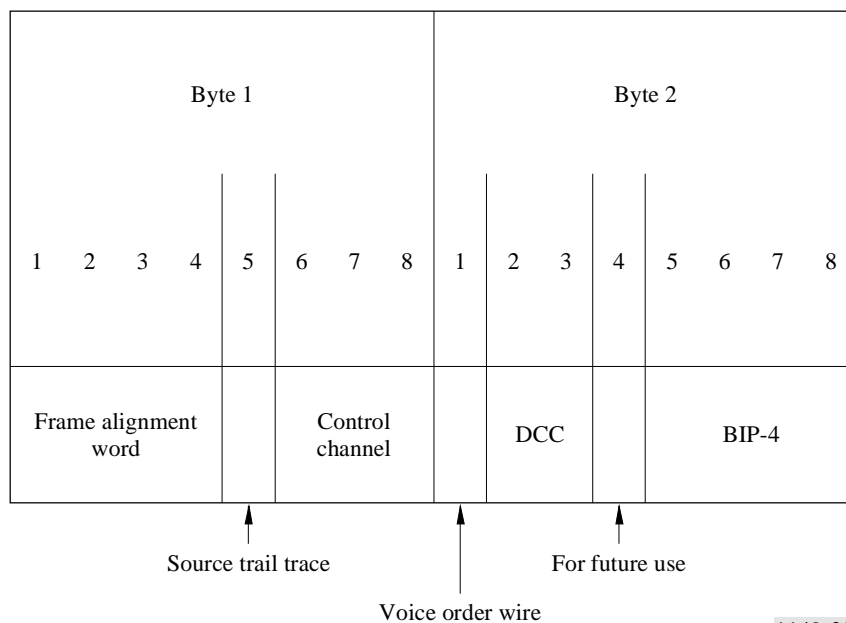The exact method of synchronization is an implementation matter.

The FAW pattern is 32 bits in length and the default value when expressed in Hex format is A04E9EC5.

Other carefully chosen 32 bits sequences could be employed in special circumstances by the default sequence should be used wherever possible.

Source trail trace (8 bits, 1 bit per frame)

The source trail trace indicates to the receiving destination(s) the identity of the origination station. Thus the receiving station can verify its continued connection to the intended transmitter. This information element employs a 1 ms frame (8×125 μs) over which the origin trail trace bits are collected. Every 125 μs a single bit is transmitted creating an 8 bit address unique to each station within the network. The addresses are assigned as part of the network configuration process.

Control channel (24 bits, 3 bits per frame)

The control channel conveys alarm and service messages, and enables payload reconfiguration. The control channel mechanism is described in § 5.3.5.

Voice order wire (VOW) (1 bit per frame)

This bit is used for VOW communication providing a 8 kbit/s encoded voice channel. The VOW channel is addressed to one or more destinations to support conferencing facility. The call set-up and clearing including addressing are performed using the service messages supported by the control channel.

DCC (2 bits per frame)

These bits are used to form a 16 kbit/s DCC. The DCC is addressed to one or more destinations. The DCC protocol and message multiplexing mechanism as well as the method of addressing the DCC to a specific destination are described in Annex 1.

For future use (1 bit per frame)

1 bit of the SSOH is reserved for future use.

BIP-4 (4 bits per frame)

These bits are used to transmit a BIP-4 value computed over all bits of the previous SSTM frame.

5.3.5 Control channel mechanism

The control channel (CC) contains 3 bits transmitted every 125 μs. The control channel employs a 1 ms CC frame (8×125 μs) over which bits are collected. A complete CC message consists of 24 bits.

Each CC message specifies an action to be taken at the following 1 ms CC frame boundary. If no new action is to be taken at the next CC frame, a refresh mechanism shall refresh the last commands transmitted on a per destination basis.

NOTE 1 – The exact definition of the refresh mechanism is for further study.

The information content of one CC message collected over a period of 1 ms CC frame is organized as follows:

FIGURE 23

SSOH control channel structure

1 2 3 4 5 6	7 8	9 1 1 1 1 1 0 1 2 3 4	1 1 5 6	1 1 1 2 2 2 7 8 9 0 1 2	2 2 3 4
Alarm destination number	Alarm message type	Service destination number	Service message type	VC-12 payload No.	VC-12 payload type

1149-23

Alarm destination number (bits 1-6)

This field conveys the destination number for which alarm information is transferred. Destinations from 1 to 63 can be addressed although currently no more than 18 destinations can be active (SSTM-26). The number 00000 specifies that all destinations are addressed (broadcast). The type of alarm is transmitted in the next field.

In each 1 ms control frame one alarm for one destination can be transmitted. If more than one alarm exists, the alarms shall be transmitted in the order of their detection or in ascending destination number.

Alarm message type (bits 7-8)

Up to four different alarm types can be specified. Currently the following messages are used:

00   REI start

01   REI stop

10   RDI start

11   RDI stop.

Service destination number (bits 9-14)

This field conveys the destination number for which a service message is transferred. Destinations from 1 to 63 can be addressed although currently no more than 18 destinations can be active (SSTM-26). The number 00000 specifies that all destinations are addressed (broadcast). The type of service message is transmitted in the next field.

In each 1 ms control frame one service message for one destination can be transmitted. If more than one service message is required, the service messages shall be transmitted in ascending destination number.

Service message type (bits 15-16)

Up to four different service message types can be specified. Currently the following messages are used:

00   VOW call start

11   Stop

01   Reserved

10   Reserved.

VC-12 payload number (bits 17-22)

This field conveys the VC-12 payload number within an SSTM-1*n* or SSTM-2*k* frame. Payload numbers from 1 to 63 can be specified although currently no more than 18 payloads can exist (SSTM-26). The number 00000 indicates that all payloads are specified. A VC-12 payload can be set to various types of transport thus enabling future applications such as compression, billing information, etc.

VC-12 payload type (bits 23-24)

Up to four different VC-12 payload types are specified.

00   Set VC-12 payload to equipped

01   Set VC-12 payload to un-equipped

10   Set VC-12 payload to ATM cells

11   Reserved.

5.3.6   Section bit rates

TABLE 4

Sub-STM-1 synchronous signal, payload, SSOH and bit rates

Designation	Payload		SSOH	S-IOS
	Composition	Rate (kbit/s)	Rate (kbit/s)	Rate (kbit/s)
SSTM-11	$1 \times$ TU-12	2 304	128	2 432
SSTM-12	$2 \times$ TU-12	4 608	128	4 736
SSTM-21	$1 \times$ TUG-2	6 912	128	7 040
SSTM-22	$2 \times$ TUG-2	13 824	128	13 952
SSTM-23	$3 \times$ TUG-2	20 736	128	20 864
SSTM-24	$4 \times$ TUG-2	27 684	128	27 812
SSTM-25	$5 \times$ TUG-2	34 560	128	34 688
SSTM-26	$6 \times$ TUG-2	41 472	128	41 600

NOTE 1 – The need for a higher maximum SSTM-2n is for further study.

5.3.7   Pointer processing and Doppler buffers

Data (SDH payload) loss due to plesiochronous clock differences between interconnected synchronous digital networks is avoided by the SDH justification mechanism controlled by the TU pointer processing. Motion buffers for the removal/reduction of phase variations due to satellite Doppler shall be integrated with the SDH TU pointer processing in the SBE (receive side) as shown in Fig. 24.

FIGURE 24

**SBE integrated TU pointer and Doppler processing
(LSSA receive side)**
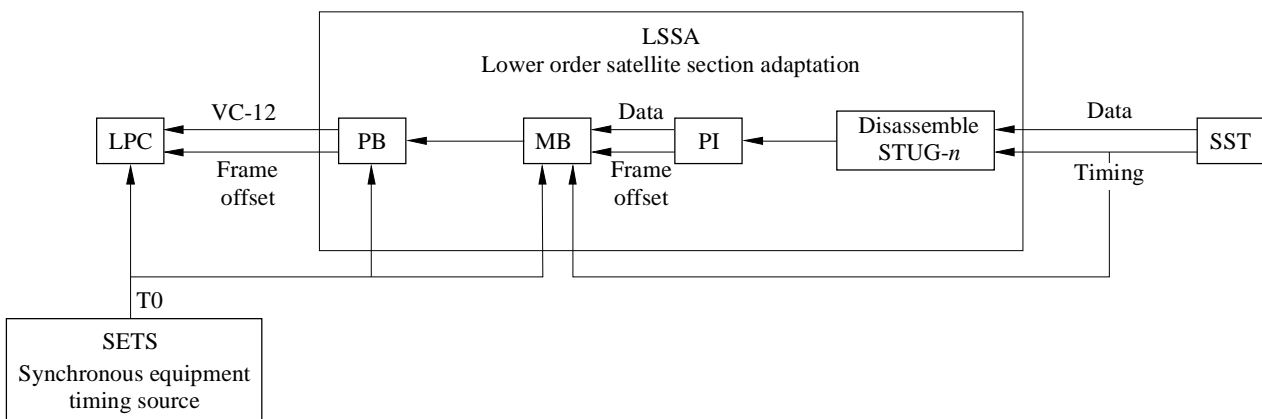
MB: motion buffer
PB: pointer buffer
PI: pointer interpreter

1149-24

Although the figure shows the pointer buffer (PB) and motion buffer (MB) as functionally distinct entities, they can be more efficiently implemented by a common physical element.

The basic algorithm of TU pointer processing is given in ITU-T Recommendation G.783.

5.3.8   TU pointer byte interleaving

Additional protection against satellite transmission error bursts shall be provided by byte interleaving the TU pointer bytes in the LSSA. The interleaving algorithm is for further study.

5.3.9   Alarm conditions and consequent actions

FIGURE 25

Scenario 3 OAM model
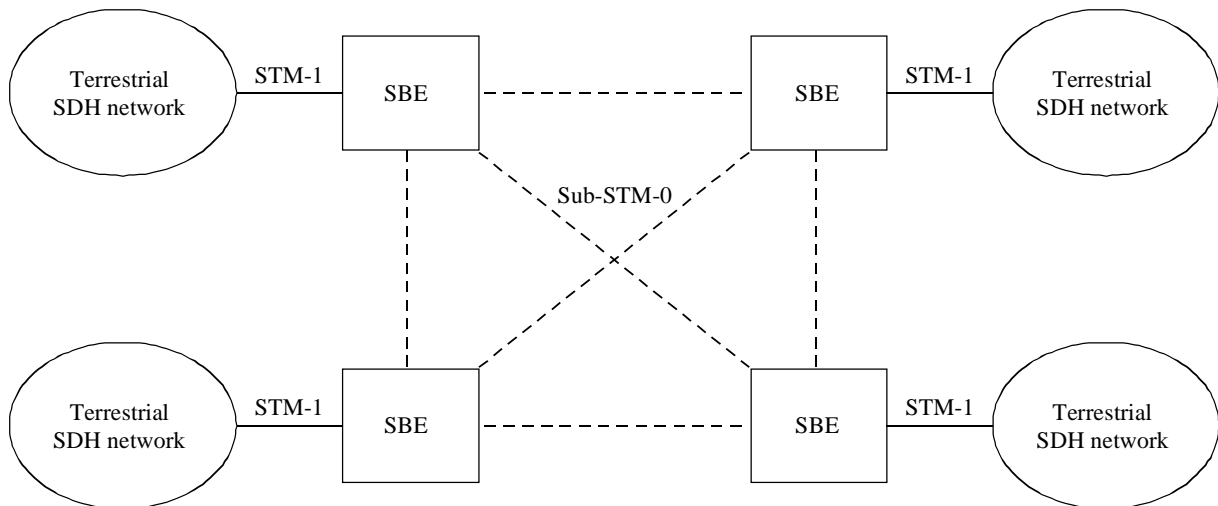
1149-25

The SBE shall detect LOS/LOF on the satellite section, and shall indicate to the downstream multiplexer of the terrestrial SDH network either the MS AIS, AU-AIS, or TU-AIS depending upon the number of AU/TUs affected, and shall indicate to the upstream SBE the satellite section S-IOS RDI signal.

The SBE shall detect LOP on the satellite section, and shall indicate to the downstream multiplexer of the terrestrial SDH network the TU-AIS, and shall indicate to the upstream SBE the LO-RDI signal.

In multi-destination operation, the satellite section RDI signal is received by more than one upstream SBE; therefore, addressing of the upstream SBE for which the satellite section RDI signal is intended, is necessary to ensure proper operation.

The fault conditions and consequent actions for scenario 3 are summarized in Table 5. LOS, LOF, LOP and MS AIS are defined in ITU-T Recommendation G.783. MS RDI, HO-RDI, LO-RDI, AU-AIS, TU-AIS are defined in ITU-T Recommendation G.707.

The time interval between the detection of LOS/LOF/LOP and the transmission of AIS and RDI signal, the duration of AIS and RDI signals, and the time interval between the termination of LOS/LOF/LOP and the removal of AIS and RDI signal are for further study.

TABLE 5

Fault conditions and consequent actions taken by the SBE in scenario 3

Interface	Failure condition	Consequent actions taken by the SBE[1]										
		Signal generated towards local terrestrial network						Signal generated towards local SEMF	Signal generated towards remote SBE			
		MS AIS	MS RDI	AU-AIS	HO-RDI	TU-AIS	LO-RDI		S-IOS AIS	S-IOS RDI	TU-AIS	LO-RDI
Local terrestrial network interface	LOS/LOF		Yes					Yes	Yes			
	MS AIS		Yes			Yes		Yes				
	MS RDI							Yes				
	AU-LOP				Yes			Yes			Yes	
	AU-AIS				Yes						Yes	
	HO-RDI											
	TU-LOP						Yes	Yes			Yes	
	TU-AIS										Yes	
	LO-RDI											
Satellite network interface	LOS/LOF	Yes[2]				Yes[3]		Yes		Yes[4]		
	S-IOS AIS							Yes		Yes[4]		
	S-IOS RDI							Yes				
	TU-LOP					Yes[3]		Yes				Yes
	TU-AIS											
	LO-RDI											

[1] A "Yes" in a table entry signifies that the specified action shall be taken by the SBE as a consequence of the fault condition. A blank in a table entry signifies that the specified action shall not b taken by the SBE because either the fault condition is not visible to the SBE or no action is required from the SBE as a consequence of the fault condition.

[2] In multi-destination, applied when LOS/LOF occurs on all received signals.

[3] In multi-destination, applied on relevant TU signals.

[4] Includes addressing of the upstream SBE for which the MS RDI is intended (in multi-destination operation).

ANNEX 1

SSOH DCC serial channel protocol

Introduction

An SDH transport system may pass through several network operator management domains as illustrated in Fig. 26 with the DCC carried management messages being terminated at each network management boundary. These management messages pass between manager systems and management agents. The management agents translate these messages into network element level measurements or actions. Thus the management view of a network is just a collection of management intelligences and their associated management information bases (MIBs) which contain the description of the objects under management, as shown in Fig. 27.

1   The serial channel protocol

To provide more flexible support for the management features of SDH transport networks, the DCC bytes are employed to form a serial communications channel to carry management messages.

Such a channel requires a protocol stack. A lower layer protocol to correct errors, provide flow control and support addressing and a higher layer protocol to support statistical multiplexing and identify message types.

Higher layer control functions such as the message queueing algorithm and the concatenation of longer messages strings are outside the scope of this Recommendation.

Given that the transmission media will be a geostationary satellite and that the transmission speed may increase, as more facilities are added, to several hundred kbit/s, then it is recommended that the service specific connection oriented protocol (SSCOP), is employed as the layer 2 protocol. SSCOP is defined in ITU-T Recommendation Q.2110 (previously Q.SAAL).

To be consistent with the way SSCOP is used in the new Q.2100-series of ITU-T Recommendations, a special simple version of the service specific coordination function (SSCF) is defined for this SDH application based on the contents of ITU-T Recommendation Q.2130 SSCF for the UNI of the B-ISDN.
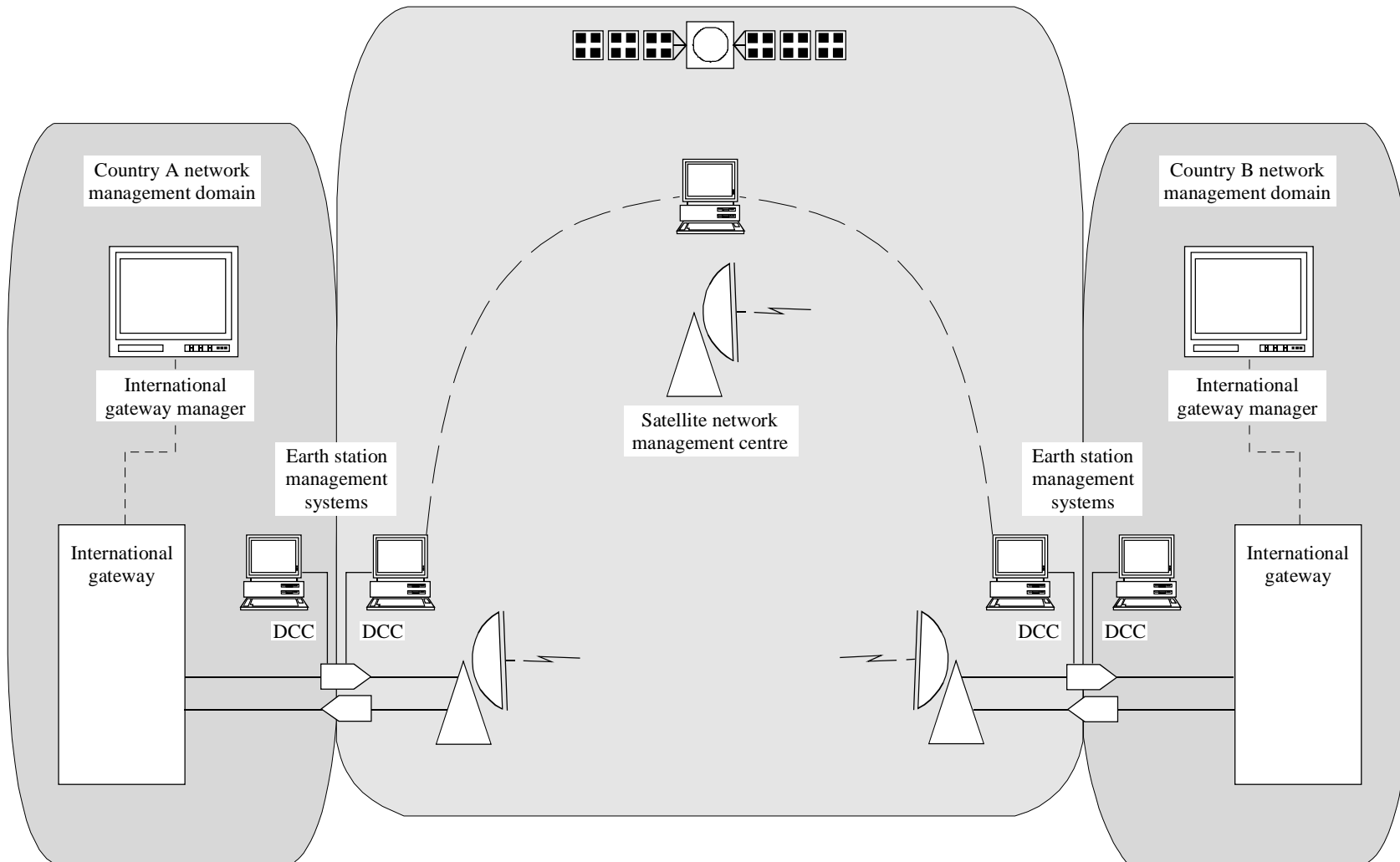
The signals between the SSCF element and the SSCOP element as illustrated in Fig. 28 are those listed in Table 6.

TABLE 6

Signal name	Function	Contents
ESTABLISH	To establish assured information transfer	None
RELEASE	Termination of connection	None
DATA	Assured transfer of data	Data string for transfer
RESYNCH	Resynchronizes one direction of transmission	
ERROR	A response indicating that SSCOP needs help	Cause number
UNIT DATA	To transfer non-assured data	Data string for transfer e.g. J0
RELEASE BUFF	A command to clear all buffers	

Unless otherwise indicated all these signals can be either requests or responses. Full details of signal structures, state tables and SDLs are given in ITU-T Recommendations Q.2110 and Q.2130. UNIT DATA transfers do not require initialization of the protocol via ESTABLISH/RELEASE states.

FIGURE 26

Management domains

Country A network
management domain

International
gateway manager

Earth station
management
systems

International
gateway

DCC   DCC

Satellite network
management centre

Country B network
management domain

International
gateway manager

Earth station
management
systems

International
gateway

DCC   DCC

1149-26

FIGURE 27

The management view of a network

MIB

Domain 2 manager

MIB

Domain 1 management agent

MIB

Domain 2 management agent

MIB

Domain 2 management agent

MIB

Domain 3 management agent
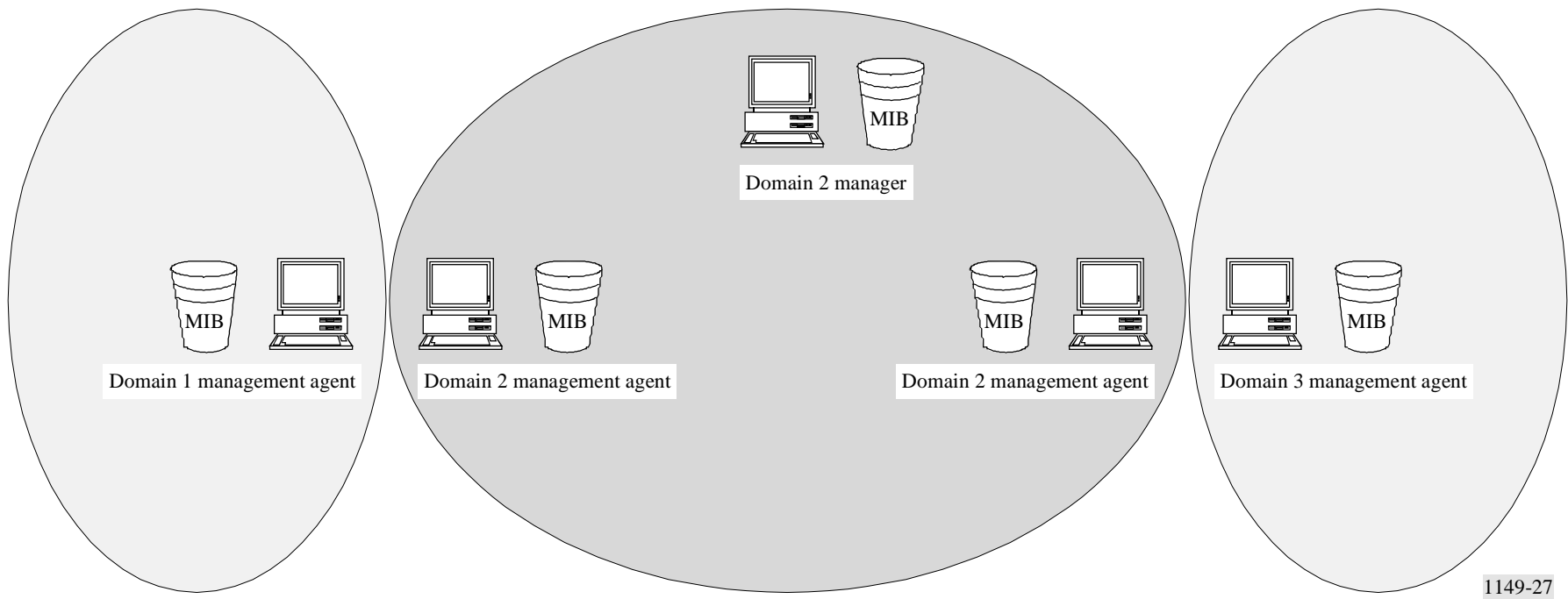
1149-27

FIGURE 28

Protocol element relationship

Message primitives

SSCF
Service specific coordination function

SSCOP
Service specific connection oriented
peer-to-peer protocol

Physical interface

1149-28
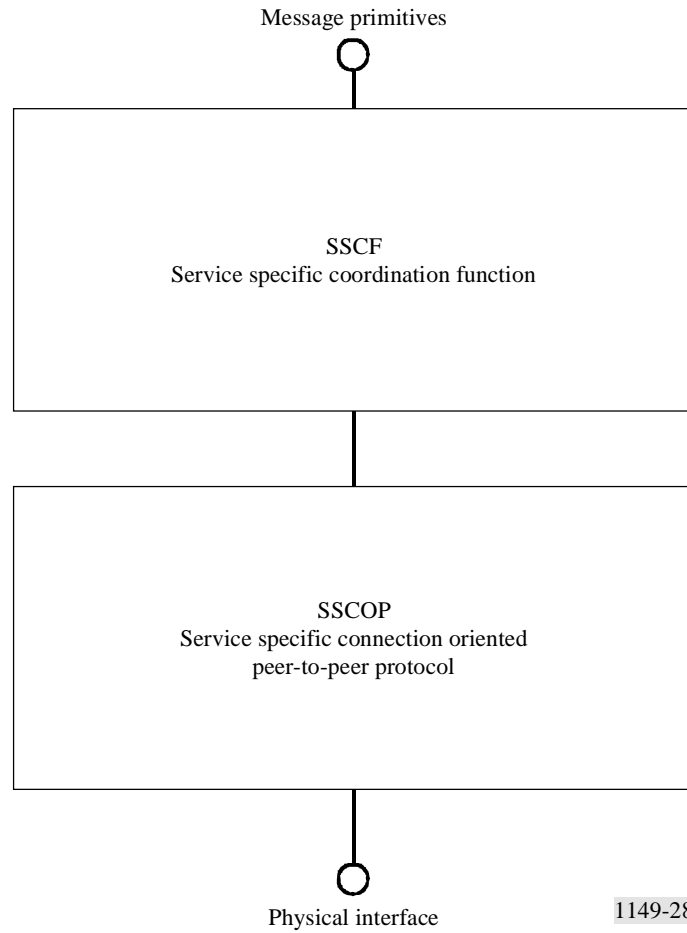
1.1 Physical layer

SSCOP is designed to operate on top of various different physical layers. In this application the physical layer is a non-contiguous string of bytes which have no restrictions on their contents, and with byte synchronization provided by the SSOH structure. Onto this base has to be applied a method for forming and synchronizing a frame structure and a method for detecting errors. Thus it is recommended that the frame structure and the frame delimiting process, using unique flag bytes, as defined in ISO Standards 7776 and 8885 for the XID frame are adopted including the use of the optional 32 bit CRC for error detection. The XID format identifier shall be 84H which is allocated in ISO 4335 (see Fig. 29).

FIGURE 29

SSOH DCC signal frame format

LSB first out

FLAG	ADDRESS	CONTROL	XID FORMAT IDENTIFIER	SSCOP INFORMATION	CRC_32	FLAG

1149-29
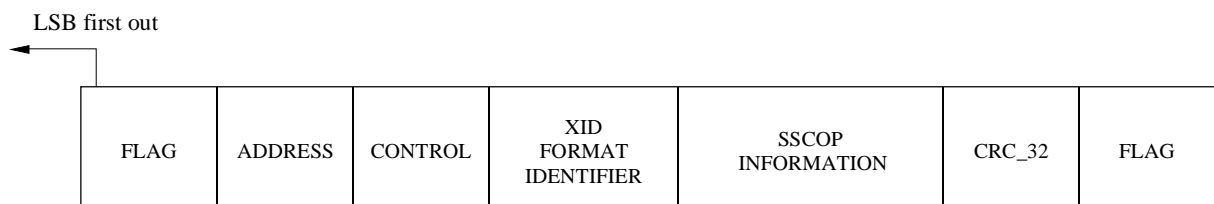
SSCOP replaces the related protocol procedures defined in ISO 4335. For example, there is no need for a SABME/UA exchange to initialize a link layer. This is consistent with the normal usage of XID frames which may be exchanged "prior to data link establishment" and avoids duplication of the SSCOP establishment process.

The XID frame is composed of a number of fields which are defined in Table 7.

TABLE 7

Field name	Value	Usage
FLAG	01111110	At least one flag between frames
ADDRESS	11100111	Mandatory
CONTROL	11110101	Mandatory
FORMAT ID	00100001 (84H)	Mandatory
INFORMATION	SSCOP information	At least 8 bytes of SSCOP address information
CRC_32	Dependent on frame contents	Mandatory

The order of bit transmission is least significant bit (LSB) first.

1.2 Special SSCF for SDH transport systems

1.2.1 The message primitives supported at the interface to the top of the SSCF are:

TABLE 8

Signal name	Function	Contents
ESTABLISH	Establish connection to distant terminal	None
RELEASE	Release connection	None
DATA	Transfer data in assured mode	Data string
UNIT DATA	Broadcast data in non-assured mode	Data string e.g. J0

1.2.2 SSCOP timers

TABLE 9

SSCOP timer	Duration (s)
TIMER_POLL	0.7
TIMER_NO-RESPONSE	2
TIMER_KEEP-ALIVE	2
TIMER_IDLE	10
TIMER_CC	1.5

1.2.3   SSCOP parameters

TABLE 10

SSCOP parameter	Description	Value
Max SD/UD/MD-PDU length	Maximum number of bytes per PDU information field	2 048
Max UU field length	Maximum number of bytes in UU field	1 024
MaxCC	Maximum number of retransmissions of BGN, END, ER, or RS PDUs	20
MaxPD	Max of VT(CC) before sending a poll	16
MaxSTAT	Max number of list elements in a STATPDU before it is segmented	67 (default)
Clear-buffers	Permission to clear buffers on connection release	Yes
Credit	Management message	Yes initially

2   Multipoint operation

To extend the definition of the serial channel to include point-to-multipoint topology with each branch having its own assured data transfer service requires that SSCOP supports multiple state-machines, one for each leaf. This mode of operation is not yet defined for SSCOP but it only requires the addition of two address fields in the SSCOP protocol data units (PDUs), one for the source address and the other for the destination address. The interface definition is extended by simply including an address field in the ESTABLISH, RELEASE and DATA messages:

TABLE 11

Signal name	Function	Contents
ESTABLISH	Initialize connection to given address list	Address list
RELEASE	Release connection to given address list	Address list
DATA	Transfer data in assured mode to given address list. Note this address list must be within the establishment address list	Address list + data

The address length is 4 bytes and employs T.51 alphanumeric codes.

The SSCOP PDU is 32 bit aligned and trailer oriented, i.e., the protocol control information is at the end of the PDU.

The source address 32 bit field and destination address 32 bit field are the first two fields in that order in the PDU information field.

3   Message structure for the serial channel

3.1   Presentation standard

The serial channel will employ 8 bit bytes coded according to ITU-T Recommendation T.51.

The LSB is transmitted first.

3.2   Message structures

The message structure will be based on ITU-T Recommendation X.209 which defines a simple type, length, variable (TLV) style of message. ITU-T Recommendation X.209 also defines a content description byte which is not required in this application. Thus all messages will start with a two byte header; type, length, followed by the variable part of the message.

Examples of the Type code tables for the current generation of SDH are shown in Table 12.

TABLE 12

SOH Type codes (example)

00	Reserved and protected from access by end users
01	Reserved and protected from access by end users
02	J0 byte content
03	Reserved and protected from access by end users
04	S1 byte bits 1-4 content
05 to 0C	Reserved and protected from access by end users
0D	D bytes content (this code may never be used as each individual kind of traffic which uses a serial channel should have its own Type code)
0E to FF	Reserved and protected from access by end users

A single byte "length byte" is defined as this limits the length of messages and avoids blocking of the serial channel by overly long messages. Multibyte length fields are used in other applications but are not allowed here. It is the responsibility of the transmitter to control the priority of the messages. There is nothing in the message protocol to indicate priorities.

The Type byte is the first byte of the contents of the SSCOP PDU. In this multipoint version of SSCOP this will be the byte after the destination address.

The speed of the serial channels (the number of bytes involved) does not effect the message structures or the protocol.

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