ETSI TS 102 402 V1.1.1 (2005-05)

Technical Specification

Satellite Earth Station and systems (SES);
Broadband Satellite Multimedia;
Transparent Satellite Star - A (TSS-A);
DVB-S and DVB-RCS for transparent satellites;
Sub-family 1 (TSS-A1)

ETSI

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

Introduction

While the DVB-S standard [3] enables broadband services via satellite in one direction, the need for a return channel via satellite has appeared. This was standardized by DVB-RCS standards [2] and [8].

DVB-RCS may be described as a development of VSAT systems which already offer broadband services such as Internet access, multicasting, VPN. DVB-RCS is the easy way to provide interactive broadband over satellite.

A DVB-RCS based network can be configured as a star network, which supports communications in the forward channel from the Hub station to many Terminals, functioning according to DVB-S, and in the return channel from the Terminals to the Hub station.

We envisage here a solution suitable for both the professional and the residential markets.

1 Scope

The present document has been produced by the ETSI Technical Committee Satellite Earth Station and Systems (TC SES) Broadband Satellite Multimedia (BSM) working group. It defines BSM air interface subfamily Transparent Satellite Star - A1 (TSS-A1) using DVB-RCS and DVB-S with transparent satellite so support interworking with IP multimedia and services.

The reference architecture (or BSM family, see [1]) is TSS i.e. the satellite is Transparent (bent-pipe), the network is configured according to a Star topology and the return channel passes through the Satellite; the A is to designate the first family envisaged in this family of BSM specifications; the 1, the first subfamily in the TSS-A family [7].
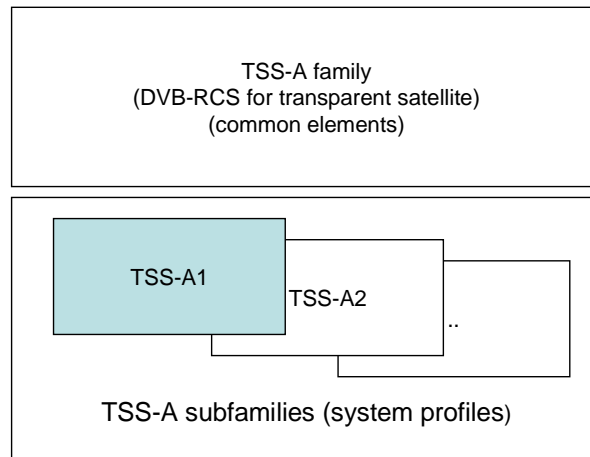
Figure 1: BSM TSS-A Air Interface Family document structure

The present document is based on the baseline DVB-RCS specification as defined by the SatLabs System Recommendations [15]. Nonetheless, the choice has been made to fully describe some concepts in the present document in order to be self explanatory or to refer to the original standards [2] and [8] where the appropriate level of precision can be found.

The key issue of the present document consists of explaining how to map functions or parameters defined above the Satellite Independent Services Access Point (SI-SAP) to the layers downward the SI-SAP (grey part of figure 2, extracted from TR 101 984 [4]).
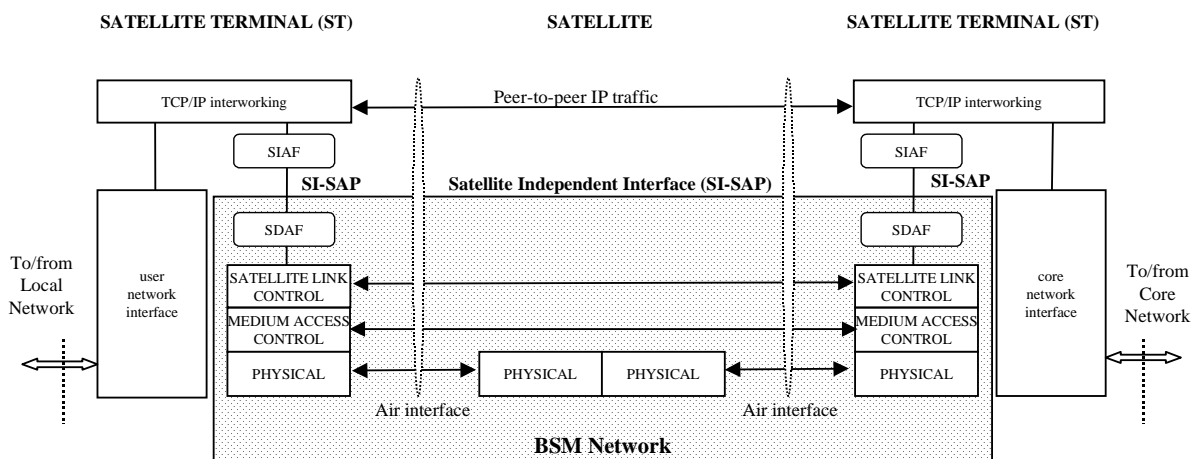
Figure 2: Satellite sub-network layering

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

[1] ETSI TR 102 187: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia; Overview of BSM families".

[2] ETSI EN 301 790: "Digital Video Broadcasting (DVB); Interaction channel for satellite distribution systems".

[3] ETSI EN 300 421: "Digital Video Broadcasting (DVB); Framing Structure, Channel Coding and Modulation for 11/12 GHz Satellite Services".

[4] ETSI TR 101 984: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia; Services and Architectures".

[5] ETSI TR 101 985: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia; IP over satellite".

[6] ETSI EN 301 192 (V1.2.1): "Digital Video Broadcasting (DVB); DVB specification for data broadcasting".

[7] ETSI EN 102 352: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia; Transparent Satellite Star -A (TSS-A) DVB-S/DVB-RCS for transparent satellites".

[8] ETSI TR 101 790: "Digital Video Broadcasting (DVB); Interaction channel for satellite distribution systems; Guidelines for the use of EN 301 790".

[9] ETSI EN 300 468: "Digital Video Broadcasting (DVB); Specification for Service Information (SI) in DVB systems".

[10] ISO/IEC 13818-1: "Information Technology - Generic coding of moving pictures and associated audio information: Systems".

[11] IETF RFC 1901: "Introduction to Community-based SNMPv2".

[12] IETF RFC 1213: "Management Information Base for Network Management of TCP/IP-based internets: MIB-II".

[13] IETF RFC 1155: "Structure and identification of management information for TCP/IP-based Internets".

[14] ETSI TR 101 202 (V1.2.1): "Digital Video Broadcasting; Implementation Guidelines for Data Broadcasting".

[15] SatLabs System Recommendations.

NOTE: http://satlabs.org

[16] IETF RFC 2684: "Multiprotocol Encapsulation over ATM Adaptation Layer 5".

[17] ETSI TR 102 287: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); IP Interworking over satellite; Security aspects".

[18]   ETSI ETR 289: "Digital Video Broadcasting (DVB); Support for use of scrambling and Conditional Access (CA) within digital broadcasting systems".

[19]   IETF RFC 1112: "Host extensions for IP multicasting".

[20]   IETF RFC 2401: "Security Architecture for the Internet Protocol".

3   Definitions and abbreviations

3.1   Definitions

For the purposes of the present document, the terms and definitions given in EN 301 790 [2], TR 101 790 [8], SatLabs System Recommendations [15] and the following apply:

bearer service: telecommunication service that provides the capability of transmission of signals between access points

broadcast: communication capability which denotes unidirectional distribution to an unspecified number of access points connected to the network

control plane: plane which performs the call control and connection control functions, and deals with the signalling necessary to set up, supervise and release calls and connections

data piping: mode for conveying data over protocols of the DVB family where discrete pieces of data are delivered using containers (MPEG2 packetized elementary streams) to the destination without any control information

data streaming: mode for conveying data over protocols of the DVB family where the data takes the form of a continuous stream which may be Asynchronous (i.e. without timing, as for Internet packet data), Synchronous (i.e. tied to a fixed rate transmission clock, as for emulation of a synchronous communication link) or Synchronized (i.e. tied via time stamps to the decoder clock and hence to other PES packets, as for the display of TV captions)

Digital Video Broadcasting Return Channel Satellite (DVB-RCS): protocol for an interaction (or return) channel in satellite links

Digital Video Broadcasting via Satellite (DVB-S): protocol for broadcasting TV signals and by extension data over satellite

management plane: Plane which provides two types of functions, namely layer management and plane management functions

multicast: communication capability which denotes unidirectional distribution from a single source access point to a number of specified destination access points

Quality of Service (QoS): measure of the parameters of a network that influence perceived quality of communications, including the delay, jitter, bandwidth, and packet loss that packets sent by the application experience when being transferred by the network

Transmission Control Protocol (TCP): protocol above IP which provides a reliable, connection oriented, end-to end transport service between hosts

transparent (or bent pipe) satellite: satellite which converts the frequency of incoming signals and amplifies them, the desired carriers as well as the undesired noise, without any additional processing

turbo coding: the most recent and a high performance error correction coding scheme which has proven to be the most efficient in most cases

user plane: Plane which has a layered structure and provides for user information flow transfer, along with associated controls (e.g. flow control, recovery from errors, etc.)

VSAT systems: satellite networks designed to offer broadband services to companies by the means of small dishes

3.2 Abbreviations

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

AAA	Authorization Authentication Accounting
AAL5	ATM Adaptation Layer version 5
ACQ	ACQuisition
ATM	Asynchronous Transfer Mode
AVBDC	Absolute Volume Based Dynamic Capacity
BSM	Broadband Satellite Multimedia
CA	Conditional Access
CRA	Continuous Rate Assignment
CSC	Common Signalling Channel
DAMA	Demand Assigned Multiple Access
DSP	Digital Signal Processing
DVB-RCS	Digital Video Broadcasting Return Channel by Satellite
DVB-S	Digital Video Broadcasting via Satellite
FCA	Free Capacity Assignment
FLSS	Forward Link Sub-system
GPS	Global Positioning System
IP	Internet Protocol
ISP	Internet Service Provider
LAN	Local Area Network
MAC	Medium Access Control
MF-TDMA	MultiFrequency Time Division Multiple Access
MIB	Management Information Base
MMT	Multicast Mapping Table
MPEG2-TS	MPEG2 Transport Stream
NAT	Network Address Translation
NCC	Network Control Centre
NCR	Network Clock Reference
NMS	Network Management System
OAM	Operation Administration Maintenance
PID	Programme IDentifier
PSI	Program Service Information
QoS	Quality of Service
RBDC	Rate Based Dynamic Capacity
RF	Radio Frequency
RLSS	Return Link Sub-system
SAC	Satellite Access Control
SI	Service Information
SI-SAP	Satellite Independent-Services Access Point
SNMP	Simple Network Management Protocol
SYNC	SYNChronization
TBTP	Terminal Bursts Time Plan
TCP	Transmission Control Protocol
TIM	Terminal Information Message
TRF	TRaFic
TSS	Transparent Satellite Star
VBDC	Volume Based Dynamic Capacity
VPN	Virtually Private Network
VSAT	Very Small Aperture Satellite Terminal

4   Architecture

4.1   Overall architecture

4.1.1   Star topology

The sub-network envisaged, hereafter called "the Satellite sub-network", is composed of Satellite Terminals (STs) and a Hub Station (or Hub for short). It is configured as a star network: a Satellite Terminal can only communicate to the Hub; communication to another Satellite Terminal shall pass through the Hub.
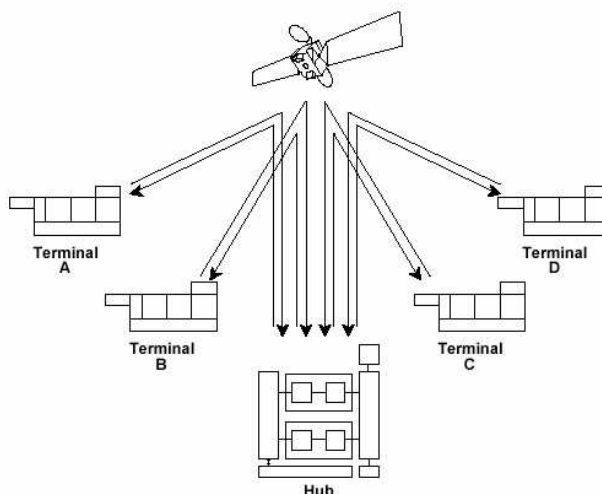
Figure 3: Typical star network with four terminals communicating via a central Hub station
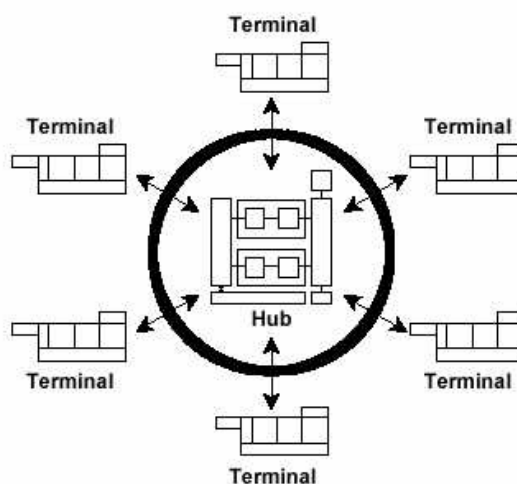
Figure 4: An overall star of communication channels between the terminals in a six stations network

There are however two other possible architectures based on DVB-RCS technology, namely TSM (Transparent -Satellite return channel - Mesh connectivity) or RSM (Regenerative - Satellite return channel - Mesh connectivity) architectures, which implement the BSM network and are defined in [1].

4.1.2 Connectivity

The Satellite sub-network shall be able to be connected to terrestrial backbones at the hub.

The STs shall be able to be connected to a local network of Ethernet type. This local network should not be connected to a network other than the Satellite sub-network; see clause 5.2.

4.1.3 Transparent Satellite

It is assumed that the Satellite sub-network uses a Transparent Satellite.

4.1.4 Satellite Forward and Return Channels

A bi-directional channel shall be established between the Hub and the Satellite Terminals for interaction purposes. It is formed by:

- **a Return (or Interaction) Channel,** from the Satellite Terminals to the Hub, which shall be used to make requests to a service provider, to answer questions or to transfer data;

- **a Forward Channel,** from the Hub to the Satellite Terminals, which shall be used to provide content from a service provider to the Satellite Terminals and any other required communication for the interactive service provision.

Forward and Return channels are used in the User, Control and Management Planes.

The Forward Channels shall be compliant with the DVB-S standard [3]; the Return Channels with DVB-RCS standard [15].

4.2 Hub station

4.2.1 Overview

Where the Satellite sub-network is connected to a terrestrial backbone, the Hub should be the only interface between them; see clause 5.2.

The Hub is composed of:

- a router, routing IP streams coming either from a terrestrial network if any or from the Satellite sub-network;

- a Forward Link Sub-system (FLSS) which processes the signal intended for the Forward Link;

- a Return Link Sub-system (RLSS) which processes the signal coming from the Return Link;

- an RF equipment for conversion from the Intermediate Frequency to the Radio Frequency on the Forward Link and the reverse conversion on the Return Link;

- the Network Control Centre (NCC);

- the Network Management System (NMS) responsible for central (including the STs) and local (i.e. Hub specific) management functions.

Figure 5: Hub Station for TSS-A1

The Network Management Server manages most of the devices. For the sake of clarity, its links with the devices have not been depicted. Its role is further specified below.

4.2.2 Interface to a terrestrial network

Where the Satellite sub-network is connected to a terrestrial network at the Hub, the router shall forward IP packets from the terrestrial network via the FLSS and conversely via the RLSS to the terrestrial network. The Hub router shall provide the IP routing functionality needed to select one outgoing terrestrial interface between several in order to forward IP datagrams.

The router has a two-way interface with the NMS for the purpose of its own management.

The terrestrial network may be, for example, a backbone, a LAN, a wireless LAN, etc.

4.2.3 Forward Link Sub-system

The FLSS receives either video signals, IP datagrams from the router or Signalling from the NCC (e.g. system time); it converts them in DVB-S format and transmits the resulting signal to the RF chain.

The ability to process video signals is mandatory; see clause 6.2.

4.2.3.1 DVB Gateway

The DVB Gateway encapsulates its input into MPEG2 packets and multiplex these packets in a MPEG2 Transport Stream (MPEG2-TS); see clause 6.3.1.

It has a two-way interface with the NMS for the purpose of its own management.

4.2.3.2 DVB-S signal format

A DSP converts the MPEG2-TS into DVB-S format; see clause 6.4.1.

The DSP gets synchronized by the NCC.

This DSP has a two-way interface with the NMS for the purpose of its own management.

4.2.4 Return Link Sub-system

The RLSS processes the signals coming from the RF chain and sent by the STs; these signals shall conform to the DVB-RCS norm; see clause 6.4.2.

It performs demodulation and decoding of the DVB-RCS signals by means of a DSP; then it extracts IP datagrams that it transmits to the router, or signalling e.g. capacity requests that it transmits to the NCC.

The devices on the RLSS (DSP, ATM Cells analyser) have a two-way interface with the NMS for the purpose of their own management.

4.2.5 Network Management System

The NMS performs the management functions for the Hub equipment and the STs.

The NMS provides means to configure, supervise, monitor, and collect performance data of:

- the Hub's sub-systems;

- the STs.

The NMS plays an essential role in commercial operations of the Satellite sub-network. It shall manage the profiles of the STs and the status of their subscription (e.g. capacity consumed) thus enabling authentication and access to the satellite capacity. (These functions must not be confused with the AAA functions of ISPs).

More details are given in clause 9.

4.2.6 Network Control Centre

The NCC controls the connection of STs to the satellite sub-network (authentication); it allocates satellite resources based on the profiles of the STs collected by the NMS, the requirements of the STs and satellite capacity available. It processes a number of tables describing this allocation and broadcasts them. It accounts for the resource consumed by STs.

It is responsible for system synchronization; it broadcasts a system time reference; it synchronizes the DSPs of the FLSS and RLSS respectively.

The NCC has a two-way interface with the NMS for the purpose of its own management.

More details are given in clause 8.

4.3 Satellite Terminal

4.3.1 Overview

In TSS-A1, the ST shall be of type A as defined in [2], clause 8.1.1.

The ST functional architecture is similar to that of the Hub; see clause 4.2.1.

A ST is formed with:

- a Interworking Unit between the local network if any and the Satellite sub-network;

- a Satellite Terminal Return Link Sub-System (ST RLSS) which processes the signal to be transmitted to the Satellite;

- a Satellite Terminal Forward Link Sub-System (ST FLSS) which processes the signal received from the Satellite;

- a Management agent working in close relation with the NMS and in charge of managing local devices;

- a Control Unit working in close relation with the NCC;

- an RF chain (comprising RF controller, RF equipment and Antenna).

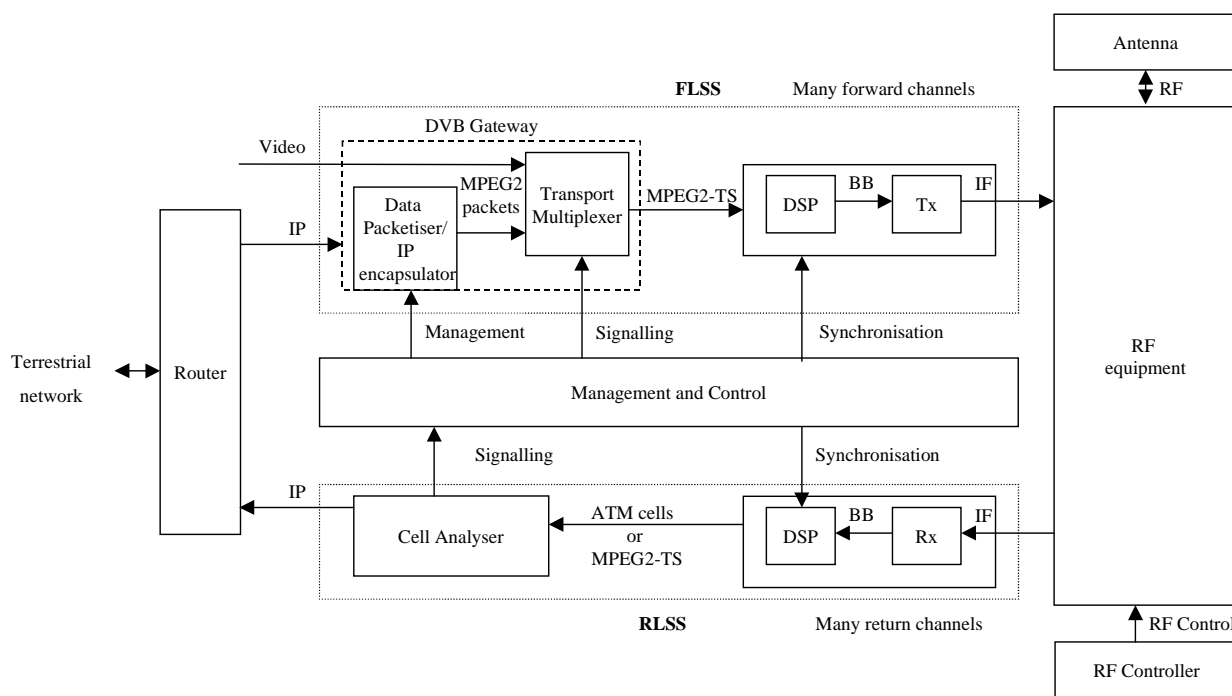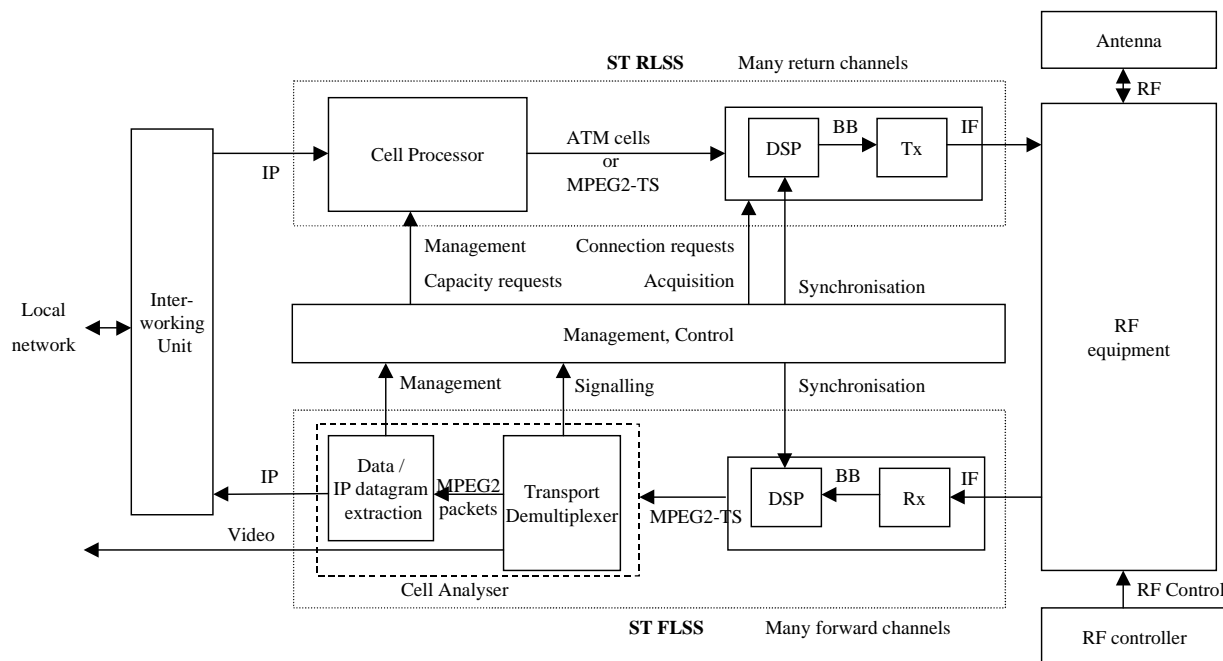**Figure 6: ST for TSS-A1**

The Management Agent manages most of the devices. For the sake of clarity, the links with the devices have not been depicted. Its role is further specified below.

4.3.2   Interworking Unit

The Interworking Unit is the interface between the local network (LAN) attached to any ST and the Satellite sub-network. It shall have routing capabilities and two IP addresses, the one on the air interface, the other one on the local interface (if any).

The Interworking Unit need not manage any routing tables in any direction:

- in the return direction, the IP datagrams are always forwarded to the air interface;

- in the Forward direction, only address resolution is required.

The Interworking Unit has a two-way interface with the Management agent for the purpose of its own management.

4.3.3   Satellite Terminal Return Link sub-system

The ST RLSS receives either IP datagrams from the Gateway or Signalling from the Management or the Control Unit (e.g. capacity requests); it converts them in DVB-RCS format suitable for satellite and transmits the resulting signal to the RF chain.

4.3.3.1   Cell processor

The ATM cell processor encapsulates IP datagrams in AAL5, and then in ATM cells, then in Traffic Bursts (see clause 7.2). In addition, the processor may support encapsulation of ATM cells in MPEG2 Transport Streams as a bridge to the physical layer.

It encapsulates Signalling into bursts of a specific format depending on its type (see clause 8.2).

It has a two-way interface with the Management agent for the purpose of its own management.

4.3.3.2   DVB-RCS signal format

A DSP converts the ATM cells (or alternatively the MPEG2-TS) into DVB-RCS format suitable for satellite (see clause 6.4.2).

The DSP gets synchronized by the Control Unit.

It has a two-way interface with the Management agent for the purpose of its own management.

4.3.4   Satellite Terminal Forward Link sub-system

The ST FLSS receives a DVB-S signal from the satellite; it extracts an MPEG2-TS, sorts the different types of payload (IP datagrams, video, signalling) and transmits each type of payload to the proper device.

It may be able to process an MPEG2 video signal.

4.3.5   Management agent

The Management agent performs the management functions for the ST's equipment.

The Management agent provides means to configure, supervise, monitor, and collect performance data of the ST's following sub-systems: ST FLSS, ST RLSS, Control Unit, Interworking Unit.

The Management agent works in close relation with the NMS sending information (e.g. capability of the ST to support SNMP or the way it uses an assigned slot when no traffic is pending, etc.) and respectively receiving information (e.g. authorization, etc.).

4.3.6   Control Unit

The Control Unit enables the ST RLSS's DSP when the ST should transmit a burst according to the indications of the TBTP.

It dialogs with the NCC so as to properly acquire the signal on the Forward Link.

It is in charge of synchronization of the different devices which require it (DSP, RF chain, etc.).

It computes capacity requests to cope with the traffic coming from the Interworking Unit and with general QoS criterions (see clause 8.2.2).

It has a two-way interface with the Management agent for the purpose of its own management.

5   Internetworking with and within TSS-A1

The BSM working group has set as basic objectives in defining its architectures the capability of offering IP services and full interoperability with terrestrial IP networks [4] and [5].

5.1   Internetworking

The end-hosts attached to the STs shall be attributed an IP address and shall be offered IP Services.

The addressing policy in a LAN attached to any ST shall depend only on the local administrator.

Assumed that the Satellite sub-network gives access to the Internet, the address plan of any LAN attached to a ST may be either private or public; in the former case, Network Address Translation (NAT) shall be foreseen at the ST Interworking Unit.

Within the Satellite sub-network, end-hosts shall communicate at IP level transparently.

5.2   IP scenarios

The Satellite sub-network envisaged shall support the two following IP scenarios as defined in [4]:

- Access Network-restricted to point-to-point services;

- Content Distribution to the Edge - including point-to-point and multicast services.

In addition, the Satellite sub-network shall offer intranet capabilities i.e. it shall be able to work as a private IP network isolated from the public internet.
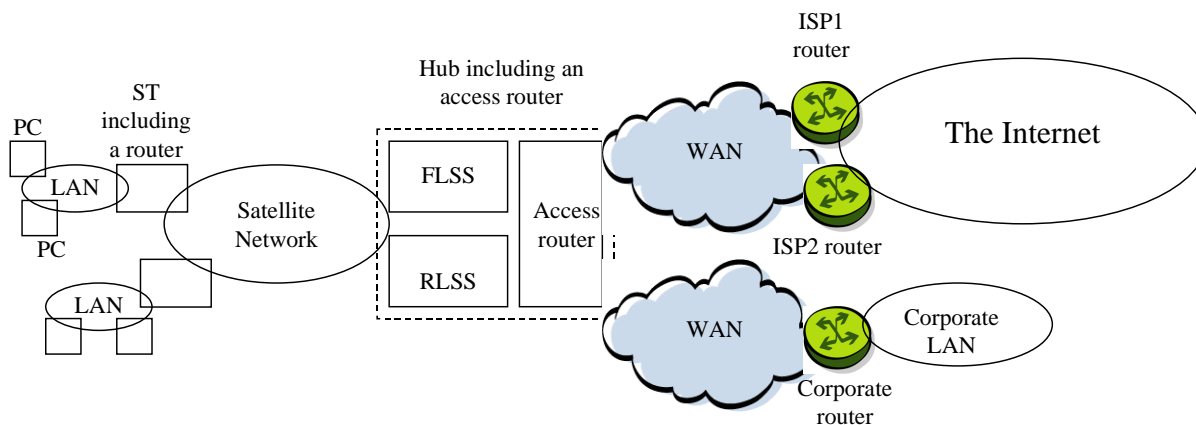
Figure 7: TSS-A1 as an Access solution

The LAN attached to any ST should not be connected to any other network (including another satellite sub-network) than the Satellite sub-network.

5.3   Main IP services

The DVB-RCS based-TSS-A1 system shall provide the following IP services:

- multicast (i.e. addressed);

- VPN;

- Unicast (UDP and TCP based applications).

5.4   Forwarding on the air interface

The address resolution mechanisms described here are based on [6] and [15].

Forwarding consists for a router in passing datagrams to the next device in the path toward the final host, also called "next hop". To that end, the router needs to know the MAC addresses of the devices (hosts or routers) within a Time To Live (TTL) of 1.

In TSS-A1, as in any star architecture, this problem is relevant only on the Forward Link. In the Return Link, the next hop is necessarily the Hub. However, STs must get the Hub's address at least once. This is done at the commissioning stage.

Two cases must be distinguished:

- unicast where the datagrams are for a single end-host identified by either its IP or its MAC address;

- multicast (which includes broadcast as a particular case) where the datagrams are for many end-hosts identified by a unique IP address.

5.4.1 Unicast

In the Forward Link, the MAC address of any ST is the MAC address of its DVB-S receiver. It shall be stored at the Hub in some data structure at the commissioning of the ST. As for the ST's IP address, if it is static, it shall also be stored at the commissioning stage; if it is dynamic there must be some mechanism (e.g. DHCP with the server on the Hub side) to associate an IP address with the ST's MAC address; this mechanism is in charge of storing address pairs.

Subsequently, the DVB Gateway shall detect IP streams, encapsulate them in MPE packets and fill in the MAC field of the packets with the ST's MAC address. If MPE packets do not have the right MAC address, they are silently discarded by the receiver.

The PID shall not be used to uniquely identify any ST (see clause 6.3.1.2).

5.4.2 Multicast and broadcast

TSS-A1 provides the multicast capability on the Forward Link.

   NOTE: Direct transmission of IP multicast (i.e. with class D or E destination addresses) is not supported on the Return Link. It is however feasible by encapsulating the multicast stream in a unicast stream and transmitting it over the Return Link to the hub; and the hub then retransmits the multicast stream over the Forward Link. This mechanism is described in [8], clause I.6.

TSS-A1 shall support static multicast: i.e. where only a given set of multicast addresses can be accepted on the Satellite sub-network.

IPv4 multicast addresses shall be converted to MPE MAC addresses according to the principles set forth in [19] for conversion of IP addresses into Ethernet addresses. This method consists basically of replacing the 23 lower bits of the Ethernet multicast address "01-00-5E-00-00-00" (in hexadecimal notation) by the 23 low-order bits of the IP multicast address.

It is to be noticed that multicast streams can be recognized at MPE level thanks to the higher bits of the MAC address.

Multicast MPE addresses are mapped to a given set of PIDs that shall be reserved for specifying multicast traffic. All multicast streams passing on the Satellite Forward Link at a given time share the same set of PIDs, irrespective from their source. The mapping is not necessarily one-to-one. It is the responsibility of the Satellite sub-network operator and it is actually made by the NCC. The NCC shall inform the STs of the current mapping by broadcasting Multicast Mapping Tables (MMTs), as required in [15].

At the reception, a first selection of streams occurs in the Cell Analyser thanks to the PID. The ST Interworking Unit shall rely on IGMP to forward (respectively discard) the multicast stream to the attached LAN.

6 Profile for DVB-S and DVB-RCS: commonalities to all planes

6.1 Satellite Independent Service Access Point

In order for interoperability with terrestrial networks to be ensured, the payload shall comply with standard, widely used formats such as IP for data. The point where adaptation to the satellite link begins (in general, by means of some encapsulation mechanism), is called the Satellite Independent Services Access Point (SI-SAP, [4]).

6.2 Types of payload

This clause addresses the types of payload carried by MPEG2 packets on the Forward link respectively ATM cells on the Return Link.

The payload may consist of:

- video including audio or subtitles; this option exists on the Forward Link only;

- control information and commands;

- IP datagrams;

- miscellaneous.

Management information and commands are a particular case of IP datagrams (see clause 9).

Unless otherwise specified, these payloads exist on both the Forward and the Return Links.

It should be stressed that TSS-A1 shall be able to be used concurrently for video (if this option is available) and multimedia.

It is recommended to restrict to the three first types of payload.

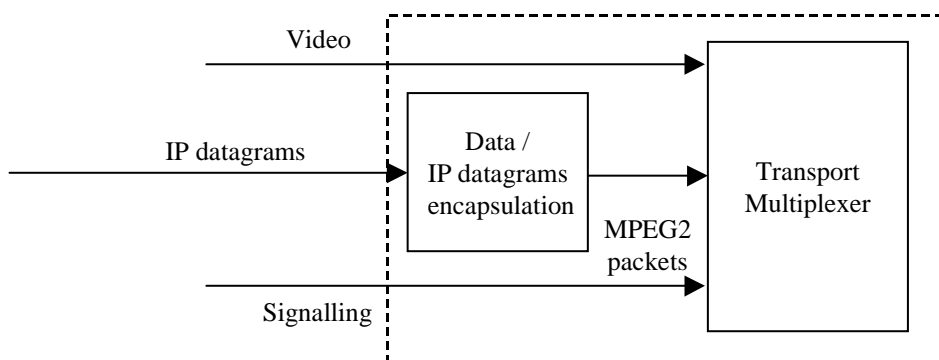The input of the multiplexer of the FLSS shall use a different port for each type of payload.

Figure 8: Multiple ports at the transport multiplexer input at the Hub

The output of the demultiplexer of the ST FLSS shall use a different port for each type of payload to benefit from demultiplexing.
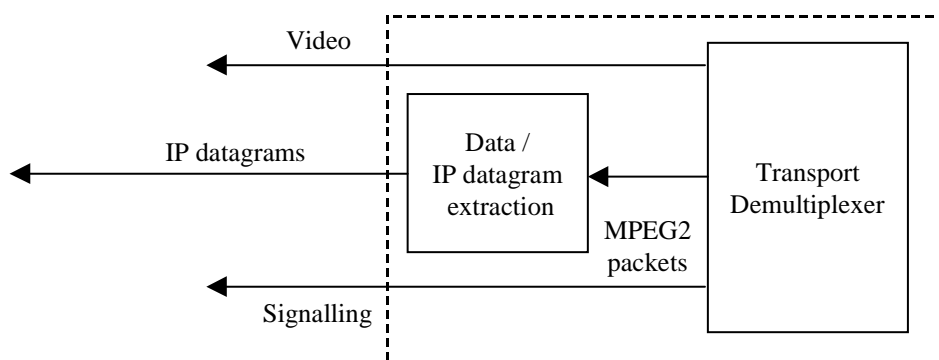

Figure 9: Multiple ports at the transport demultiplexer output at a ST

6.3   MAC and Data Link layer

6.3.1   Forward link

6.3.1.1   Multi Protocol Encapsulation

The MultiProtocol Encapsulation (MPE) [7], [14] provides a mechanism for transporting data network protocols on top of the MPEG2-TS in DVB networks by emulating a LAN. It has been optimized for carriage of the Internet Protocol, but can be used for transportation of any other network protocol by using the LLC/SNAP encapsulation. It covers unicast, multicast and broadcast.

The encapsulation allows secure transmission of data by supporting encryption of the packets.

In order to fit to MPEG2-TS, IP datagrams shall be encapsulated in MPE so that the complete protocol stack shall be IP/MPE/MPEG2-TS/DVB-S.

The MPE format is called datagram_section and is compliant with the DSMCC_section format allowing broadcasting of private data over MPEG2-TS. This eases encapsulation in MPEG2-TS.
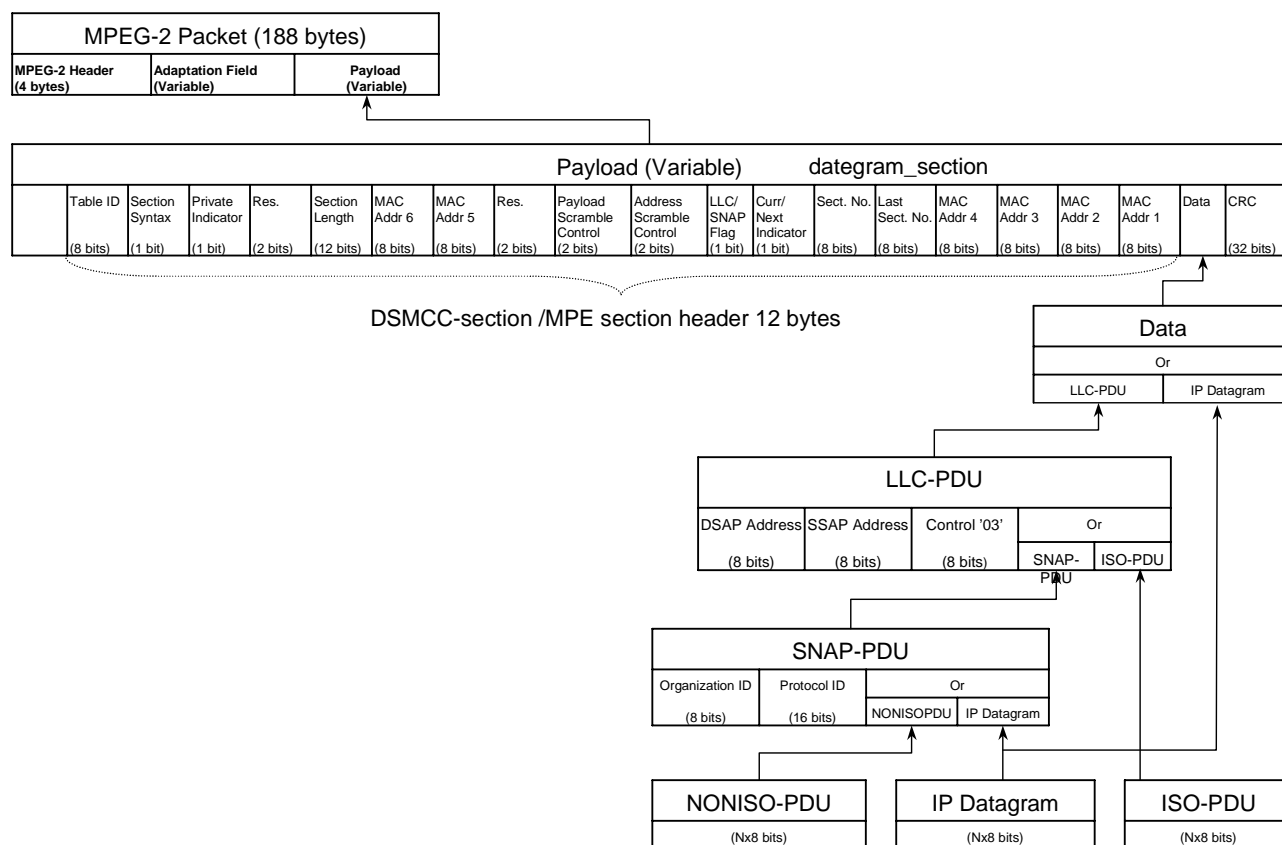
Figure 10: Multiprotocol Encapsulation

Similarly, Signalling Information (SI) tables (see clause 8.1.1) are encapsulated in DSM_CC private sections. However, the Network Clock Reference table is carried directly on top of the MPEG2 transport stream; see figure 12.

6.3.1.2   The MPEG2 Transport Stream

The MPEG2-TS [10], [7], [14] allows multiplexing and sending over the same physical channel of several MPEG2 logical channels, identified by their PID. The PID specified the source of the transport stream. The PID shall not be used to specify the destination addressee.

MPEG2-TS packets may have a transport priority flag, which provides QoS, to indicate that some packets within a stream have different priority compared to the others. This can either be within the same PID stream or among all PIDs that can be received.
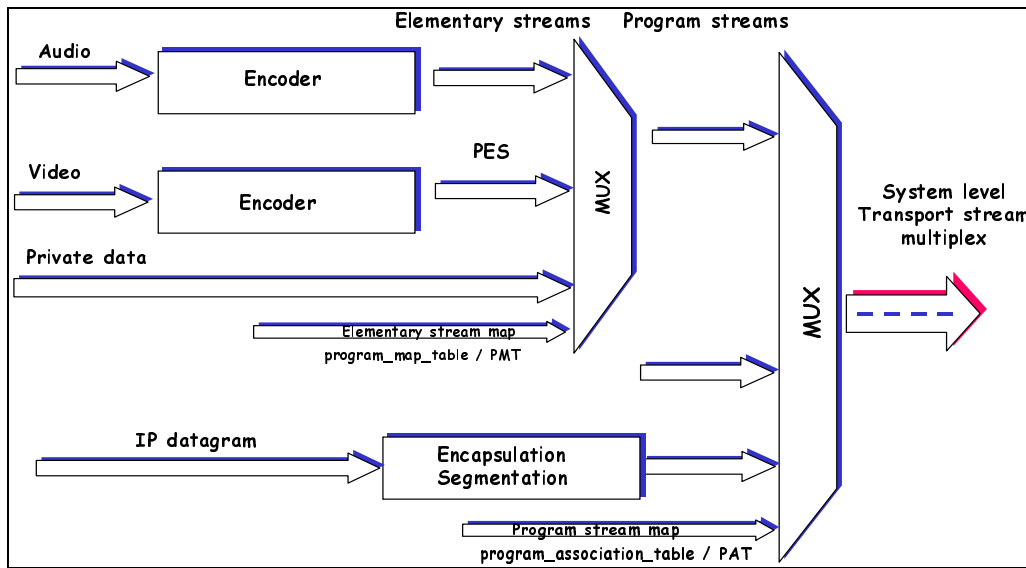
Figure 11: MPEG2-TS Multiplexing

Figure 12 represents all the protocol stacks which can be multiplexed in the Transport Stream of TSS-A1.
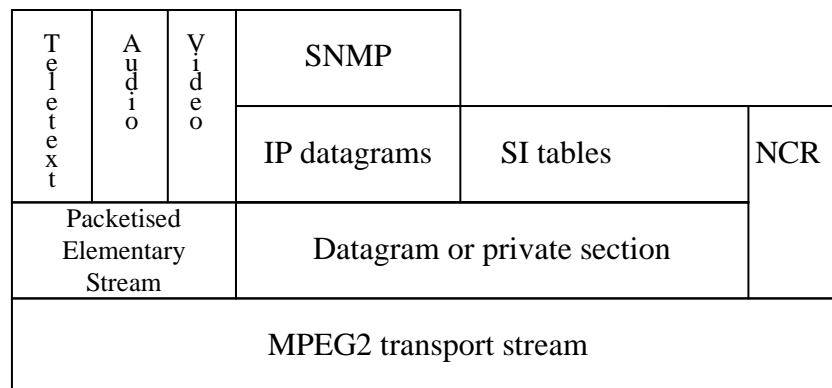
Figure 12: MPEG2-TS protocol stacks

6.3.2   Return link: multiple access and superframes

TSS-A1 shall rely on fixed MF-TDMA (Multiple Frequency and Time Division Multiple Access) to manage the resources allocated to STs; see [2], clause 6.7 and [8], clause 6.7.

MF-TDMA is based on the concept of superframe: a superframe describes how the resources are allocated to STs during a certain period and within a certain frequency range.

Basically, a superframe is a rectangle in the time and frequency plane. The frequency side is divided in bands all of the same given width and called frames; respectively, the time side is divided in bands of a given size called timeslots.

A cell at the intersection of a frequency band and of a time slot represents a unit of resource allocated to a specific ST. This uses the resource to transmit a burst carrying control information or traffic (bursts last actually a bit less than time slots they occupy). Thus a superframe can be seen as a table with two entries and with ST identifiers as values.

In a given time slot, all cells are used for the same purpose; in other words, the corresponding bursts are all of the same type. (Therefore, it is correct to speak of a TRF, respectively SYNC, CSC, or ACQ slot, like for bursts).

Traffic slots shall be all of the same duration sized to carry one or two ATM cells as per [15]. The fixed size of cells conveying traffic characterizes fixed MF-TDMA.

Typical values for superframe and slots duration are as follows:

- CSC and ACQ slots have the same duration as TRF slots; SYNC slots have half the duration of TRF slots; SYNC slots come by pair so that the total time of time slots fit to the frame duration;

- the superframe total duration should be 26,5 ms; the total bandwidth is up to the Satellite sub-network Operator.

  NOTE: Other values of superframe duration may be used.

In a superframe, CSC and ACQ slots appear first (unordered), then SYNC slots, then traffic slots. There may not be any ACQ respectively SYNC slot; see [8], clause 6.7.2.1.
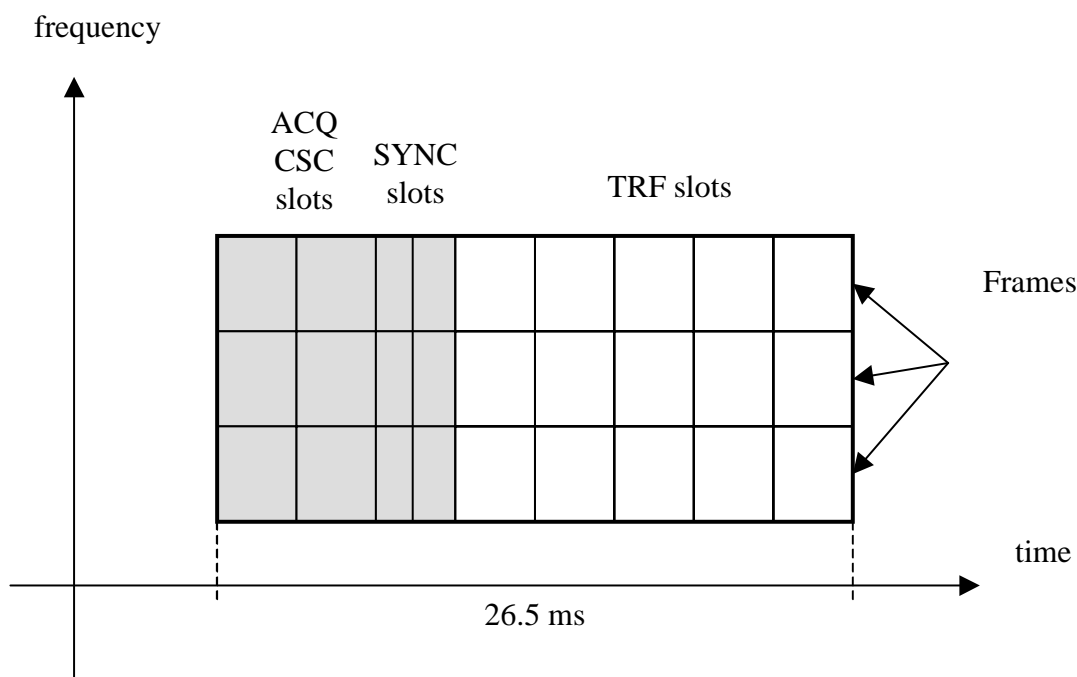
Figure 13: Typical superframe in fixed MF-TDMA

A traffic cell shall be uniquely allocated to a ST (no contention).

A ST shall be able to use any of the carriers within the superframe bandwidth. The maximum range of the frequency hop shall be either 20 MHz or 120 MHz as per [15]. The ST shall be able to hop from a frequency carrier to another one between two successive bursts (fast frequency hopping).

A sequence of superframes all of the same bandwidth and contiguous in time is labelled by a superframe identifier. Within such a sequence, every superframe is labelled by a superframe counter.

The STs are grouped in subsets characterized by one superframe identifier.
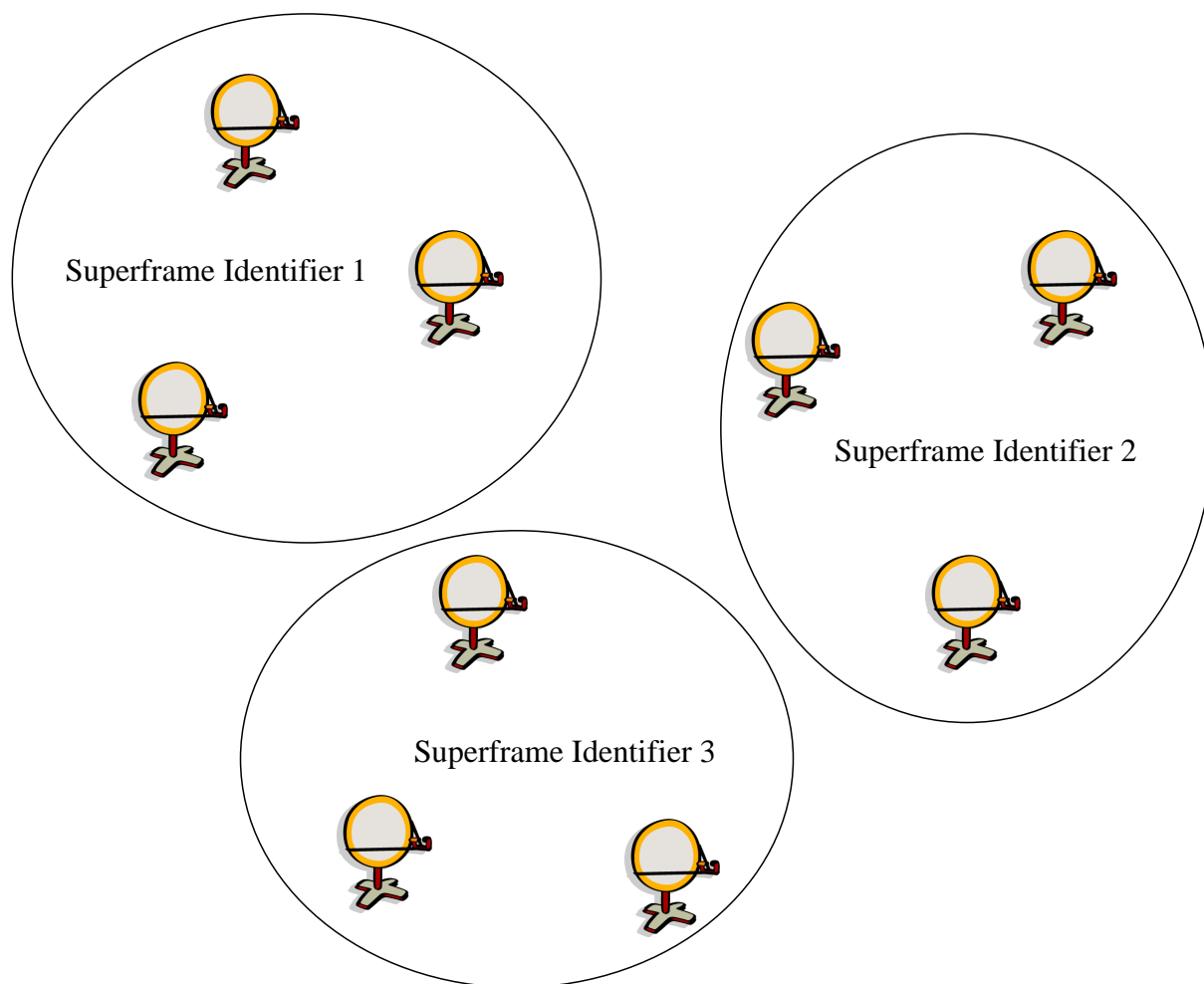
Figure 14: Typical usage of Superframe Identifiers

The NCC periodically (every frame duration) computes superframes and transmits a number of tables to STs to indicate them the superframe identifier and counter, the superframe composition (types of time slots), the distribution of resource to STs and the coding parameters which are subject to change from one superframe to the other. The set of tables used are described in clause 8.1.

6.4   Physical layer

6.4.1   Forward link

The signal shall comply with DVB-S norm as defined in [3]. This reference fully specifies the processes of randomization, outer coding, interleaving, inner coding, puncturing, baseband shaping and finally modulation leaving little room for option; however when options are possible (e.g. as for the coding rate) all these shall be available in TSS-A1.

6.4.2   Return link

6.4.2.1   General

The signal shall comply with DVB-RCS norm as defined in [2], clause 6 and [8], clause 6. Which options shall be retained in TSS-A1 is defined below.

6.4.2.2   Return link emission at the STs: burst format

Bursts shall start with a preamble for detection. They may be followed by a guard time to decrease transmitted power and compensate for timing errors. See [2], clause 6.2.

Burst shall be encoded save bursts of the ACQ type (see clause 8.2.1). Following SatLabs System Recommendations [15], TSS-A1 shall support turbo coding with default parameters defined in [2], clause 6.4.4.

In addition, TSS-A1 may support:

- a combination of outer coding with a Reed-Solomon code and inner coding with a convolutional code;

- detection by means of Cyclic Redundancy Check.

The codes to be used are further specified in [2], clause 6.4 and the recommendations for using or bypassing some stages in the coding process in [8], clause 6.4.

7   Profile in the Data plane

By definition, the data plane is the set of specifications pertaining to the transport of IP datagrams. The transport of Video (and associated payloads) is not addressed in further detail in the present document.

7.1   Forward Link: IP over DVB-S

7.1.1   Useful bit rate

The bit rate shall be configurable. The recommended range is from 1 Mbps to 50 Mbps or greater.

7.1.2   Mac and Data link layer

7.1.2.1   Addressing

The MAC address of the ST shall be located in the datagram_section. It is 48-bit long and split in two parts. The locations of the MAC address segments are specified in [6].

The MAC address may be scrambled; scrambling is controlled by means of two bits, "00" indicating that there is no scrambling. Scrambling is fully specified in [6].

In the Cell Analyser at the ST, MPE packets shall be either silently discarded if their MAC address is not that of the ST or else disassembled and transmitted to the Gateway.

7.2   Return Link: IP over DVB-RCS

7.2.1   Useful bit rate

The bit rate shall be configurable. The recommended range is 256 kbps to 2 Mbps or greater.

7.2.2   Data Link layer: ATM format

IP datagrams shall be encapsulated in ATM cells by means of the ATM Adaptation Layer 5 (AAL5), according to the specifications of [16]; the resulting protocol stack is IP/AAL5/ATM. The point in AAL5 is that it allows data to fit to a fixed ATM cell format by stuffing and thus avoids segmentation and reassembly of ATM cells. The length of ATM cells shall be 53 bytes.

An ST shall thus establish Virtual Circuits (VCs) with the Hub. The encapsulation mechanism shall be VC based multiplexing. It allows multiplexing of several VCs hence of the different types of data stream formats (not only IP datagrams) the VCs may carry.

7.2.3   Physical layer: traffic bursts

TSS-A1 shall use Traffic (TRF) bursts for carrying useful data on the return link. A TRF burst contains exactly one or two 53 bytes long ATM cell as a payload. A Satellite Access Control (SAC) field is appended to the beginning of the ATM cell(s) to transport MAC messages. The SAC field shall be two bytes long; for a two cells payload, it is recommended that TSS-A1 also support a 5 bytes length as per [15]. Beside, TRF bursts meet the general specifications of clause 6.4.2.2.
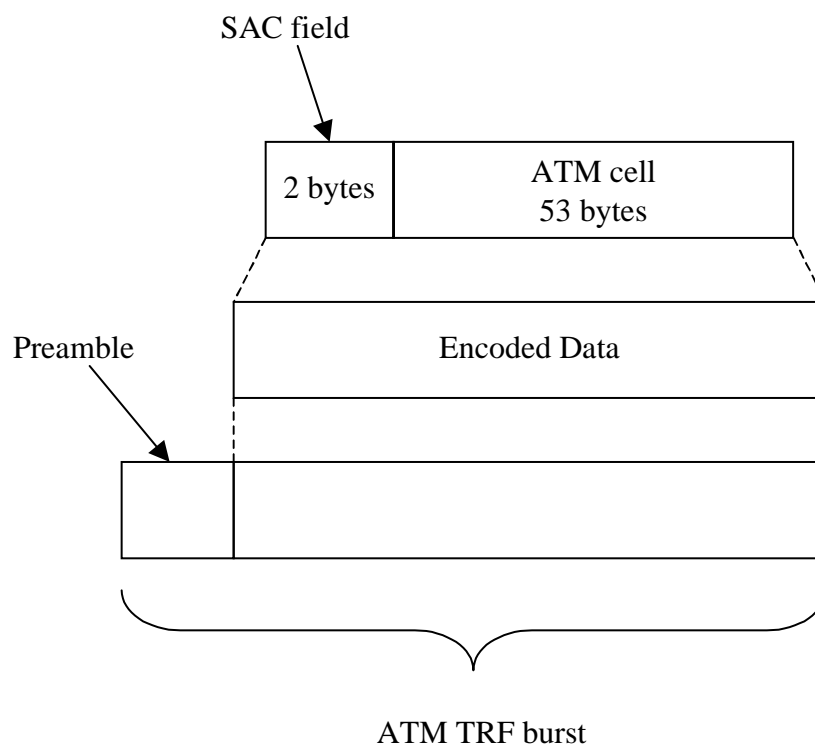

Figure 15: Insertion of an ATM cell in a TRF burst

8   Profile in the Control Plane

The Control Plane is the set of specifications pertaining to signalling and associated functions: synchronization, link establishment, resources requests and allocations.

8.1   Signalling on the Forward Link

8.1.1   General Information: Service Information tables

The Service Information (SI) in MPEG2 provides information which enables automatic configuration of the receiver and to demultiplex and decode the various streams in the multiplex. SI data are structured in tables encapsulated in DSM_CC private sections, according to MPE, and inserted in the payload of MPEG2 packets (see clause 6.3.1). Private sections carrying SI tables are characterized by a specific PID. General concepts on SI can be found in [9].

The SI tables TSS-A1 uses can be classified in two categories:

- Program Service Information (PSI) tables: the Program Association Table (PAT) and the Program Map Table (PMT); these tables enable to demultiplex the forward link signal and to reconstruct each individual stream (see [9]);

- tables specific to DVB-RCS [2], clause 8.3: Superframe Composition Table (SCT), Time slot Composition Table (TCT), Satellite Position Table (SPT), Frame Composition Table (FCT), Terminal Burst Time Plan (TBTP), Correction Message Table (CMT).

8.1.2   Terminal Information Message

The TIM message is sent by the NCC either to an individual ST addressed by its MAC address (unicast message) or broadcast to all STs using a reserved broadcast MAC address and contains static or quasi static information about the forward link such as configuration.

This message may also be used to facilitate the handing over of an ST to a different group or network group or network or to switch a group of STs to a different forward link signalling service on another MPEG2-TS for example. This message is sent in a DSM_CC private data section.

8.1.3   Network Clock Reference

The NCR carries the information required for system synchronization; see clause 8.3.1. The NCR is distributed with a specific PID within the MPEG2 Transport Stream that carries the forward link. The concept of NCR is equivalent to the concept of PCR in [10] and its distribution follows the same mechanism.

8.2   Signalling on the Return Link

8.2.1   Burst types and their format

TRF bursts have been described in clause 7.2.3. The other types of burst are CSC (Common Signalling Channel), ACQ (ACQuisition), and SYNC (SYNChronization) bursts; they are used for control and maintenance purposes. Their format is as follows:

- SYNC bursts are used for the purpose of maintaining synchronization and sending control information to the Hub. SYNC bursts are composed of a preamble, a 4 bytes long SAC field and a guard time (see figure 16). In the SAC field, one byte is devoted to the Request Sub-Field, the second one to the Monitoring and Control Sub-Field, the third one to the Group_ID Sub-Field and the last one to the Logon_ID Sub-Field;
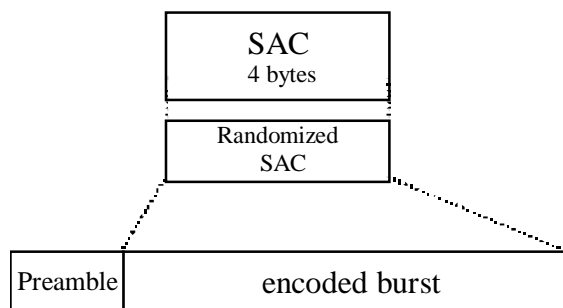
Figure 16: SYNC Burst Format

- an ACQ burst can be used to achieve synchronization, prior to operational use of the network by the Terminal. ACQ bursts are composed of a preamble, a frequency sequence and a guard time (see figure 17);

| Preamble | Frequency sequence |

Figure 17: ACQ Burst Format

- CSC bursts are only used by the Terminals to identify themselves during logon. They are composed of a preamble, a field describing the Terminal capabilities, the Terminal MAC address, a reserved field and a guard time (see figure 18).

RCST capa	RCST MAC address	CSC Rou te ID	Dynamic Connectivity	Frequency Hopping	reserved	Burst type identifier

Rand . RCST capa	Rand . RCST MAC address	Rand . CSC Route ID	Rand . Dynamic Connectivity	Rand . Frequency Hopping	Rand . reserved	Rand · Burst type identifier

Preamble	encoded burst

Figure 18: CSC Burst Format

8.2.2   Capacity requests and capacity categories

The STs shall explicitly request the NCC for capacity according to a Demand Assigned Multiple Access (DAMA) protocol.
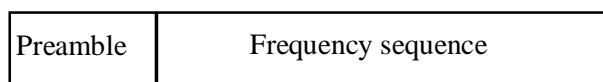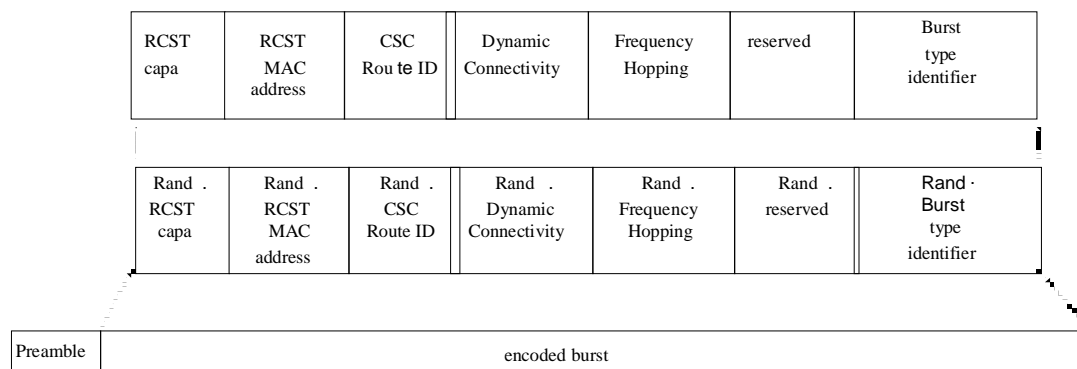
The first time a ST requests capacity, it does so by inserting its request in the SAC field of the SYNC burst (mini slot method); once a ST has got capacity, it repeats its requests again by inserting them in the SAC field appended as a header of the ATM payload in TRF bursts.

Contention access by the mini slot method shall not be authorized.

Requests are classified in four categories corresponding to the way the NCC allocates capacity; see [2], clause 6.8 and [8], clause 6.8:

- Continuous Rate Assignment (CRA) (a certain number of traffic slots per superframe);

- Rate Based Dynamic Capacity (RBDC) (a certain number of traffic slots to be provided in one superframe within a limit negotiated with the NCC). RDBC is not mandatory; the NCC can use it to complete a minimum capacity allocated as CRA as suggested in [8];

- Volume Based Dynamic Capacity (VBDC) (a total number of traffic slots which can be shared between several superframes; successive VDBC requests add up);

- Absolute Volume Based Dynamic Capacity (AVBDC) (a total number of traffic slots which can be shared between several superframes; a new AVDBC allocation cancels the previous ones).

As for RBDC requests, a time-out mechanism shall be available; by default, this shall be disabled as per [15].

Remaining capacity is designated as Free Capacity Assignment (FCA).

FCA should be distributed to STs according to the following criterions ranked by priority:

1)   performance optimization of TCP/IP e.g. reducing occurrence of timeouts;

2)   equity.

Provided that these criterions are met, FCA should be shared according to a round-robin procedure.

8.3   Synchronization

8.3.1   General

For proper functioning of MF-TDMA, the Satellite sub-network must be accurately synchronized. TSS-A1 follows the standard; see [2], clause 6.1 and [3], clause 6.1. In addition, it shall meet the following requirements.

The NCC shall provide the Satellite sub-network with a common value for the absolute time, a common symbol clock for symbol emission and a common frequency reference for generating carriers. It shall do so by broadcasting a Network Clock Reference (NCR) (see clause 8.1.3). The NCC may acquire this Reference in various ways such as consulting GPS.

The NCC shall compensate for the Doppler shift introduced on the links between itself and the Satellite.

The NCC shall not compensate for the Doppler shift introduced on the links between the Satellite and the STs; this is left to the STs (see next clause).

Each ST shall correct the NCR by subtracting the expected Forward Link transmission delay. The transmission delay can be interpreted in two different manners depending whether:

- the hub serves as the reference point for the NCR; then the transmission delay equals the time the signal takes to travel on the whole Forward Link from the hub to the ST; or

- the satellite serves as the reference point for the NCR; then the transmission delay equals the time the signal takes to travel from the satellite to the ST on the Forward Link.

As for carrier generation, each ST shall use its own oscillator which shall be tuned by means of the NCR method.

The STs shall retrieve the centre frequency, the start time and the duration of their transmit bursts by examining the TBTP. The actual start time of any transmit burst at a given ST is calculated by subtracting the expected Return Link transmission delay from the start time indicated in the TBTP.

In TSS-A1, due to fixed MF-TDMA, the Superframe Composition is fixed, the Frame Composition is fixed and the duration of the transmit bursts is fixed. Therefore there is no need to use Superframe Composition Tables nor Frame Composition Tables in principle. However the Hub shall retransmit the tables at regular intervals in order to inform newcomers of the current settings and to refresh the relevant items of information (set of frequency carriers to be used, traffic slot duration, etc.). The Time-slot Composition Table remains useful where as it carries information affecting the formatting of the traffic slots.

8.3.2   Synchronization procedures

8.3.2.1   Overall events sequencing

Prior to attempt to enter the Satellite sub-network, a ST shall achieve the **Initial synchronization procedure** by which it acquires all necessary information from the Hub. The entry is then achieved through the following four phases:

- **Logon procedure:** the ST requests initial access to the Network and gets initial logon information from the Network (or alternatively the logon request may be rejected by the Network). The ST sends its request in a CSC timeslot using Slotted Aloha random access. Once the login is successful, the ST switches to the MF-TDMA normal access mode; for the remaining of the synchronization procedure, it uses the signalling bursts allocated to it.

- **Acquisition coarse synchronization procedure:** the ST improves its physical synchronization (frequency, time, and power adjustments).

- **Fine synchronization procedure:** the ST completes its physical synchronization. The ST is now able to request some capacity by means of the minislot method.

- **Synchronization maintenance procedure:** the ST maintains its physical synchronization during the entire session.

Unless described below, the procedures are as described in the standard [2], clause 7.

8.3.2.2   Logon procedure

TSS-A1 logon procedure is enhanced with respect to the standard procedure [2], clause 7 by the additional steps shown in the shaded cells in the flow chart below:
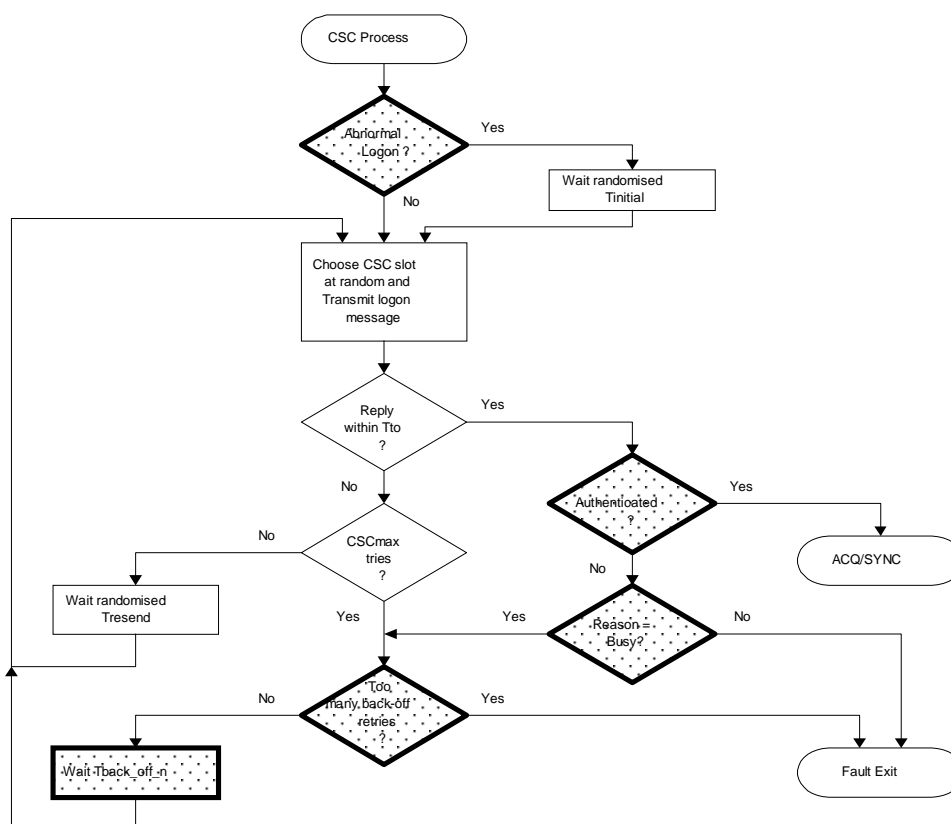

Figure 19: Logon procedure flowchart

These additional steps are included to handle abnormal logon, user authentication, and CSC repeated retry. The condition of abnormal logon can occur when for example the Forward Link has gone down. After this occurs all the STs in the Satellite sub-network will attempt to log back on. The enhanced procedure automatically regulates the re-entry of the STs by applying a randomized delay.

The step to authenticate the STs is added to explicitly show that this is required before a ST can proceed with the synchronization procedures. The step referred to above as CSC repeated retry is added to allow a ST to automatically, after a randomized delay, restart the login procedure again after it has failed to get in, in its first CSC retry loop.

8.3.2.3   Enhanced coarse synchronization procedure

This clause describes an enhanced coarse synchronization procedure which enables reduction in the login time of about 3 s. Though the standard procedure is compliant with TSS-A1, it is recommended to adopt the enhanced procedure.

At the beginning of the coarse synchronization stage, the ST shall successively:

1)   retrieve the burst correction from TIM;

2)   correct the burst position;

3)   if the burst position is within the range required then the ST shall jump to the fine synchronization stage.

The corresponding flowchart is represented below where the new steps are in the shaded cells.
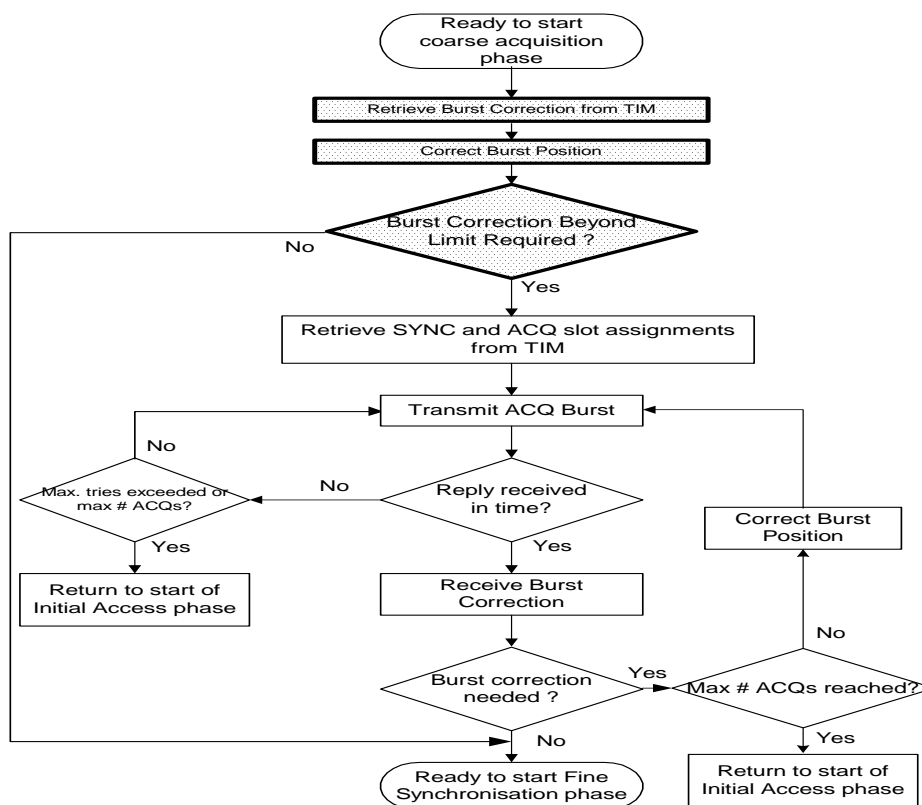
Figure 20: Enhanced coarse synchronization procedure

9   Management

9.1   General concepts and features

Management is the set of functions enabling to assess and possibly modify the level of performance of each sub-system of the Hub or each ST. These functions can be separated in five categories: fault management, configuration management, performance management, security management and accounting.

Though management is not mandatory in DVB-RCS Satellite sub-networks in general, TSS-A1 shall offer management functions. TSS-A1 management shall comply with the specifications of [8], clause 8.6.

One of the interest to have an IP based network is the capability to manage the networks according to standards discussed mainly at the IETF: Management Information shall comply with the general principles set forth in [13].

9.2   Specific vs. common functions

Some functions are specific to the Hub i.e. they enable managing certain of the Hub's sub-systems; some other are specific to the ST; the remaining ones involve information and sub-systems which can be located either at one end or the other of the Satellite link.

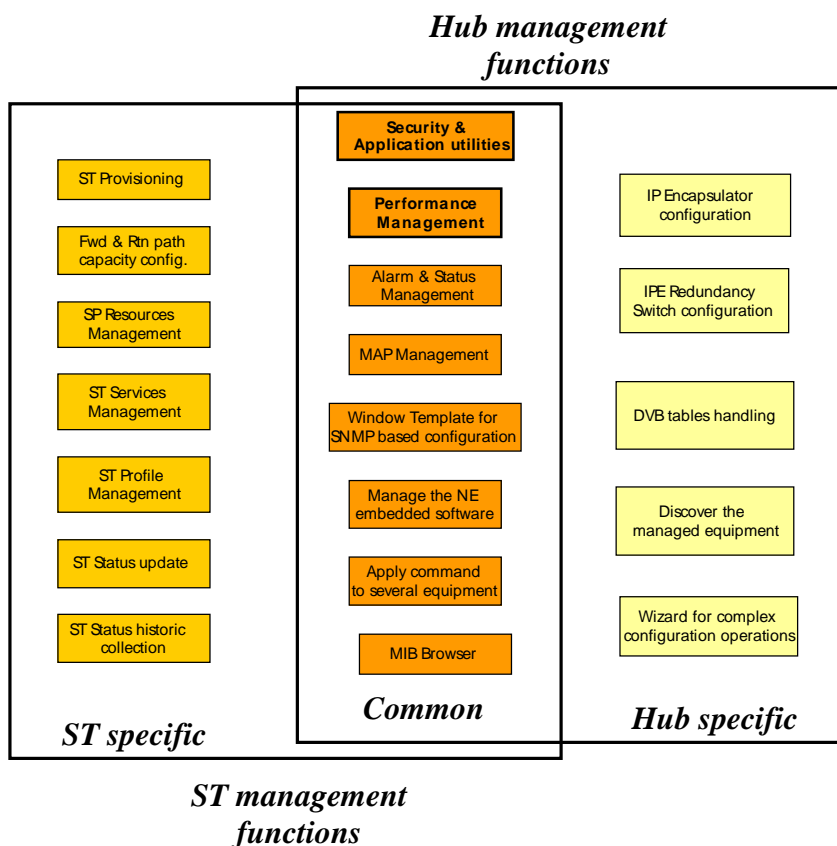The following figure clarifies the situation.

Figure 21: Repartition of management functions

9.3   Protocol

The management logic and the format of the management messages shall comply with Simple Network Management Protocol version 2 (SNMP v2) [11]. SNMP is the most usual way in which network management applications can download respectively upload data from respectively to a MIB.

SNMP is a protocol above IP; then management messages and commands are carried according to the rules pertaining to the transport of IP. However SNMP messages on the Return Link should use different Permanent Virtual Channels (PVCs) than user traffic; moreover, when it is in the Operations, Administration, Maintenance (OAM) active status, a ST is able to send SNMP messages while it is not able to send traffic.

> NOTE: While it is an option that STs support SNMP according to [8] and [15], it is mandatory in TSS-A1.

9.4   Management Information Bases

The Hub and the STs shall implement two different Management Information Bases (MIB) addressing two different sets of functions and devices whose pattern is defined by the relevant authority:

> NOTE 1: While the MIBs are optional in [8] and [15] they are mandatory in TSS-A1.

- MIB-II for TCP/IP functions. The definition of this MIB is under the responsibility of IETF and is described in [12].

- Private Enterprise RCST MIB. The definition of this MIB is under the responsibility of European Broadcasting Union and is described in [8], clause 8.6.

> NOTE 2:   Additional MIBs may also be used.

The groups and objects of the latter MIB are exhaustively described in [8], annex F.

MIBs compliant with these patterns shall be implemented in the Hub and in the STs as well. The set of objects encompassed by the union of these MIBs is referred to as "the MIB" in the following.

9.5   ST configuration

A ST with SNMP capability shall have additional states (or statuses) with respect to non SNMP capable STs. The state has one the following values: *idle*, *initialized*, *hold*, *OAM active*, *fully active*, *fault*; see [8], clause 8.6.3. However, in TSS-A1, the hub shall be capable of working with terminals that either differentiate the states *OAM active* and the *fully active* or do not differentiate them.

A ST signals its SNMP capability by the SNMP field of the ST Capability field carried in the CSC burst that is sent during logon. An NCC that wants to dialog with a ST either in the *OAM Active* status or the *fully active* status for access control shall reply with a TIM that contains a Network Layer Info Descriptor described in [8], clause 8.6.3.

A ST MIB shall be allocated a specific IP address different from the one used for carrying traffic and referred to as the OAM IP address.

9.6   Management and Control

As described in [2], clause 8.4.2, SNMP commands ensure interoperability between the NCC and the STs. The NCC obtains the current configuration parameter values from the ST MIB, in order to request transmission characteristics required for the ST. The NCC and the STs exchange SNMP messages, such as installation procedures implementation, software upgrades, authorization or prohibition of transmission, individual/group control and traffic forward link assignments, ST status enquiries, and ST or NCC requests to leave the network.

Maintaining ST profiles up-to-date is the job of the NMS.

10   Security

Radio communications are more than any other ones subject to security threats (eavesdropping, jamming). An overview of the threats and of possible countermeasures is made in [17].

The only security requirements in TSS-A1 regard the protection of resource (satellite capacity). Integrity or privacy of data/reserved access are optional.

10.1   Data protection

10.1.1   Upper layers mechanisms

In this clause, it is assumed that the payload of MPEG2 packets in the forward link respectively of the ATM cells in the return link consists in IP datagrams (see clause 6.2).

By upper layers, it is meant layer 3 and above. A typical layer 3 security mechanism is IPSec [20] which can work either in tunnel mode or in transport mode. IPSec requires some adaptations to perform efficiently over satellite; this issue is discussed in [17].

TSS-A1 shall be able to support upper layers security mechanisms. It is up to the Satellite sub-network operator or to the service provider to provide and enable these mechanisms.

10.1.2   Forward link: DVB-S Conditional Access

In this clause, it is assumed that the payload of MPEG2 packets consists of video; it is recalled that this is optional (see clause 6.2).

Conditional Access (CA) [10] is a service that allows service providers (chiefly broadcasters) to restrict certain programming products to certain viewers. The CA does this by scrambling [18] the service providers' programs. Consequently, the programs must be decrypted at the receiving end before they can be decoded for viewing. CA offers capabilities such as Pay-Per-View.

CA belongs to the baseline of MPEG2/DVB-S; therefore, as far as it supports video, TSS-A1 shall support CA. It is up to the Satellite sub-network operator or to the service provider to provide and enable this mechanism.

10.2   Protection of resource

The NCC shall authenticate the STs. Authentication takes place at logon (see clause 8.3.2.2).

In combination with authentication, the NCC and the NMS account for the resource consumed by any ST for the calculation of which amount of resource it may request. This can be seen as a protection measure.

These functions are performed at level 2 and must not be confused with the AAA functions of ISPs.

Other functions would be desirable: non-repudiation, ciphering (or scrambling) of signalling, etc.

10.3   Miscellaneous

TSS-A1 shall provide terminal barring: at any moment the Satellite sub-network Operator can logoff a ST from the network.

Annex A (informative):
Bibliography

- ETSI EN 301 192 (V1.3.1): "Digital Video Broadcasting (DVB); DVB specification for data broadcasting".

- ETSI TR 100 815: "Digital Video Broadcasting (DVB); Guidelines for the handling of Asynchronous Transfer Mode (ATM) signals in DVB systems".

- ETSI TS 102 292: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM) services and architectures; Functional architecture for IP interworking with BSM networks".

History

Document history		
V1.1.1	May 2005	Publication