Coordination Group for Meteorological Satellites

Direct Broadcast Services: LRPT/AHRPT Global Specification

Written by EUMETSAT on behalf of CGMS

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1 INTRODUCTION

1.1 Purpose and Scope

This document defines the LRPT/AHRPT Global Specification of the Direct Broadcast Services. It provides an architectural specification of the LRPT/AHRPT Direct Broadcast mission from a telecommunication point of view. Thus it does neither define meteorological (or other) application relying on this standard nor specifies a user station for LRPT/AHRPT Direct Broadcast.

1.2 Applicable Documents

The subsequently listed documents form an integral part of this specification.

- [AD.1] CCSDS: "Advanced orbiting systems, networks and data links: architectural specification", CCSDS recommendation 701.0-B-2, November 1992.
- [AD.2] ISO: "Information processing systems - open systems interconnection - basic reference model", ISO standard 7498-1, 1994.
- [AD.3] CCSDS: "Time code formats", CCSDS recommendation 301.0-B-2, April 1990
- [AD.4] CCSDS TM Synchronization and Channel Coding 131.0-B02.
- [AD.5] *AOS Space Data Link Protocol*. Recommendation for Space Data System Standards, CCSDS 732.0-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, July 2006.
- [AD.6] Space Packet Protocol, Blue Book. Issue 1. September 2003 133.0-B-1.
- [AD.7] CCSDS: "Radio frequency and modulation systems, part-1: earth stations and spacecraft", CCSDS recommendation 401.0-B, Issue 2, November 1994.

1.3 Reference Documents

The subsequently listed documents do not form and integral part of this specification. They are referenced to provide extended background information.

- [RD.3] ITU Radio Regulations.

2 ADOPTED ARCHITECTURE

The architectural model presented in the [AD.1] Advanced Orbiting Systems (AOS), Networks and Data Links: Architectural Specification is used as a basis to specify the LRPT/AHRPT Direct Broadcast Services global specifications. The main purpose of [AD.1] is to specify an architectural framework within which the Agencies participating in the CCSDS may implement compatible space mission data handling systems, so that opportunities for inter-Agency cross support and cooperation are maximized. The Architectural Specification document organises AOS, Networks and Data Links as a set of services operated with the different used networks.

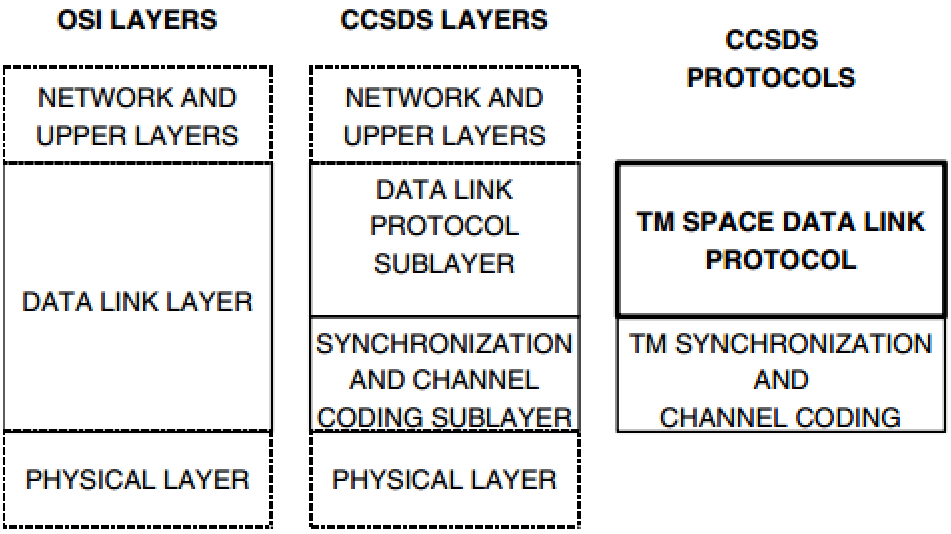

Figure 1 – Reference to OSI model

The figure above extracted from (CCSDS Recommendation for TM Space Data Link Protocol) shows the different existing CCSDS layers as well as its relationship to the OSI reference model.

For the LRPT/AHRPT global specification definition, a more detailed layered model called the “CCSDS Service layer model” is used in order to better describe the key functionalities and data units of the CCSDS specifications.

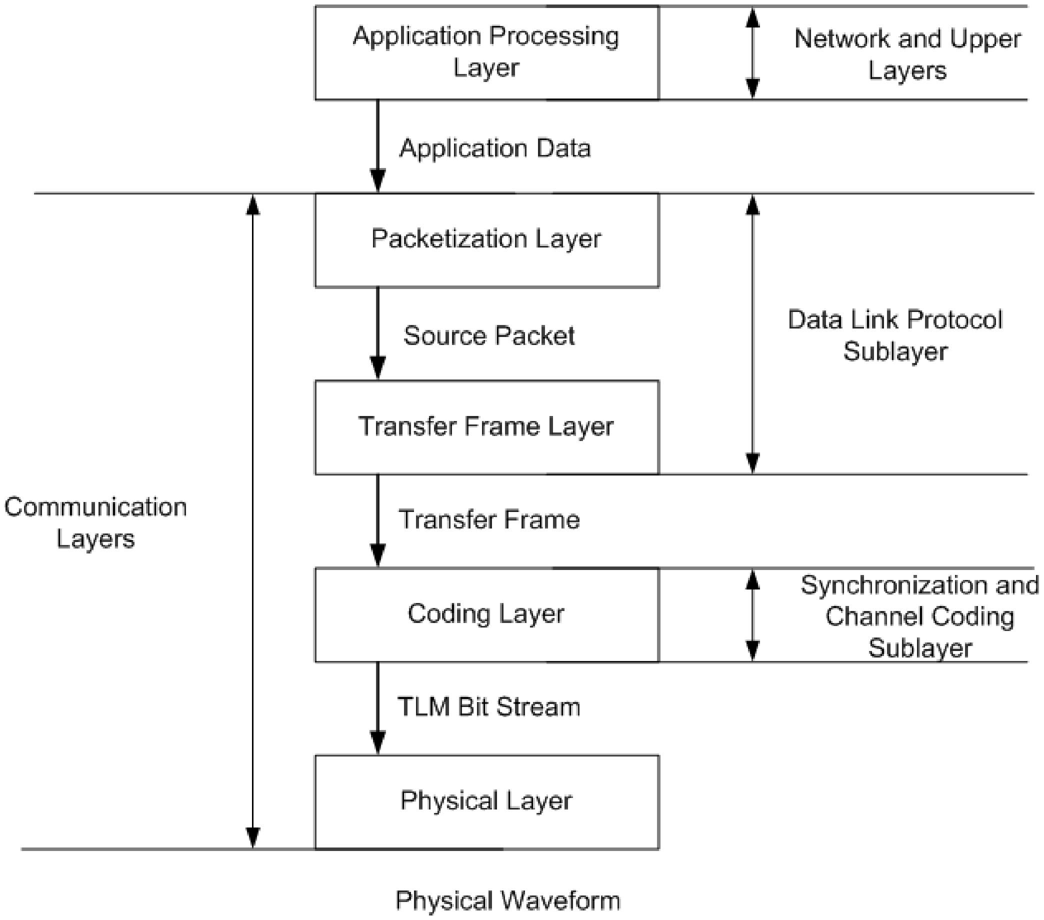

Figure 2 – CCSDS Service Layers

In the subsequent sections (2.1 to 2.5) the different service layers are outlined.

In section 3, each service layer is specified in detail when applicable.

2.1 Application Processing Layer

The application processing layer provides users a method to investigate physical phenomena by transforming satellite measuring instruments into sets of application data units. The application data units are data structures that are **mission dependant** and therefore are not defined in the present document. Examples of application data units could be radiances products coming from remote sensing data, meteorological bulletins, etc.

2.2 Packetisation Layer

Spacecraft generated application data are formatted into end-to-end transportable data units called ‘Source Packets’. These data are encapsulated within a primary header which contains identification, sequence control and packet length information. A Source Packet is the basic data unit sent to the user by the spacecraft and generally contains a meaningful quantity of related measurements from a particular source.

2.3 Transfer Frame Layer

The Transfer Frame layer is used to transport source packets within space-to-ground communication links. The transfer frame layer uses transfer frames, to transport Source Packets through the satellite communication channels to the receiving telecommunication network. Transfer Frames are fixed length units which were chosen to improve the ability to synchronize the frame within weak signals such as those found on space-ground links, and for compatibility with certain block oriented channel coding schemes.

As the heart of the CCSDS AOS system, the Transfer Frame protocols offer a range of delivery service options. An example of such a service option is the multiplexing of Transfer Frames into ‘Virtual Channels’ (VCs).

2.4 Channel Coding Layer

Synchronization and Channel Coding is used to protect the transfer frames against telemetry channel noise-induced errors. Reference [AD.4] CCSDS TM Synchronization and Channel Coding describes the CCSDS Recommended Standard for Synchronization and Channel Coding, including specification of a convolutional code, a Reed-Solomon block-oriented code, a concatenated coding system consisting of a convolutional inner code and a Reed-Solomon outer code, and of turbo codes and/or other codes.

The basic data units of the CCSDS TM Synchronization and Channel Coding which interface with the physical layer below are the Channel Symbols output by the channel encoder. Within the error detecting and correcting capability of the channel code chosen, errors which occur as a result of the physical transmission process may be detected and corrected by the receiving entity.

Full advantage of all CCSDS Telemetry System services could be realized if a project complies with all CCSDS Recommended Standards. Alternatively, projects can interface with any layer of the AOS CCSDS System as long as they meet the interface requirements as specified in the recommended standards (references [AD.4], [AD.5]).

2.5 Physical Layer

The Physical layer provides the “physical connection” via radio frequency signals between a transmitting spacecraft and the receiving station.

The physical layer transforms the bit stream received from the Channel coding layer into physical waveforms. It physically modulates the channel symbols (bit stream) into RF signal patterns.

3 DIRECT BROADCAST SERVICES (LRPT/AHRPT) GLOBAL SPECIFICATION

This section details the Direct Broadcast Services (LRPT/AHRPT) global specification using the CCSDS service layers as a basis. Each of the sub sections details in which context each individual service layer with their associated CCSDS services, protocols and data units are relevant for the LRPT/AHRPT global specification.

3.1 Application Processing Layer

The application processing layer defines how the satellite services data is transformed into data units that can be handled by the satellite users. The produced data units are passed to the communication layers in order to be transmitted. For Direct Broadcast Services (LRPT/AHRPT), the possible application of data forwarded through the communication layer has been outlined in “2.1 Application Processing Layer”.

For Direct Broadcast Services (LRPT/AHRPT), there are no global specifications related to the application processing layer as it is **mission dependant**.

3.2 Packetisation Layer

The Packetisation Layer provides means for timely transporting application information (files, application packets) while preserving its integrity and sequencing.

The Packetisation Layer for CCSDS advanced orbiting systems contains a single service, the so-called packet service that creates CCSDS Source packets.

The packet service receives application data units from the Application Processing Layer, integrate them into Source packets and forward these packets to the Transfer layer.

The packet service implements the protocols, services and procedure pertaining to the CCSDS Packets that are specified in [AD.6] Space Packet Protocol, Blue Book.

Below is described the structure of the Source Packets:

packet identification				sequence control		packet length	user data
version	type	secondary header flag	APID	sequence flag	packet sequence counter		
3 bit	1 bit	1 bit	11 bit	2 bit	14 bit	16 bit	variable
← 6 octets →							← 1 ... 8192 octets →

version	Set to 0 to specify version-1 CCSDS packet
type	Set to 0, irrelevant for AOS
secondary header flag	set to 1 if the user data begins with a header field (this is the case if sequence flags equals to one or three); set to 0 else
APID	set to 0 ... 2015, specifying the logical data path and implicitly the link priority (see explanations in 7.2.2)
Sequence flags	a) ‘00’ if the Space Packet contains a continuation segment of User Data; b) ‘01’ if the Space Packet contains the first segment of User Data; c) ‘10’ if the Space Packet contains the last segment of User Data; d) ‘11’ if the Space Packet contains unsegmented User Data.
Packet sequence counter	sequential count modulo 16384, numbering the packets on the specified logical data path specified by the APID.
Packet length	sequential count modulo 16384, numbering the packets on the specified logical data path specified by the APID.

Figure 3 – Source Packet Structure

For a detailed specification of the CCSDS Source packets used by the Direct Broadcast Services (LRPT/AHRPT) global specifications refer to [AD.10] TM Packet Telemetry.

3.3 Transfer Frame Layer

The Transfer Frame Layer receives Source Packets from the Packetisation Layer and generates as output fixed length data units called Transfer Frames. The Transfer Frame Layer provides services to reliably transport Source Packets within space-to-ground communication links. The Transfer Frame Layer also includes optional services allowing the multiplexing of data units coming from multiple processing applications into one stream of transfer frames. This done by multiplexing Transfer frames into ‘Virtual Channels’ via the Virtual Channel Generation Function and the Virtual Channel Multiplexing function.

The Transfer Frame Layer of the Direct Broadcast Services (LRPT/AHRPT) Global specification implements the services as defined in CCSDS document [AD.5] *AOS Space Data Link Protocol*.

Section 4.1 of [AD.5] defines the structure of the Transfer Frame supported by the current global specifications. The Transfer Frame main structural Components are present in the diagram below:

AOS TRANSFER FRAME				
TRANSFER FRAME PRIMARY HEADER	TRANSFER FRAME INSERT ZONE (Optional)	TRANSFER FRAME DATA FIELD	TRANSFER FRAME TRAILER (Optional)	
			OPERA-TIONAL CONTROL FIELD (Optional)	FRAME ERROR CONTROL FIELD (Optional)
6 or 8 octets	Varies	Varies	4 octets	2 octets

Figure 4 – Transfer Frame Structural Components

The Transfer Frame Primary Header is mandatory and shall consist of the following five fields, positioned contiguously, in the following sequence:

1. Master Channel Identifier (10 bits; mandatory).
2. Virtual Channel Identifier (6 bits; mandatory).
3. Virtual Channel Frame Count (3 octets; mandatory).
4. Signaling Field (1 octet; mandatory).
5. Frame Header Error Control (2 octets, optional).

TRANSFER FRAME PRIMARY HEADER						
MASTER CHANNEL ID		VIRTUAL CHANNEL ID	VIRTUAL CHANNEL FRAME COUNT	SIGNALLING FIELD		FRAME HEADER ERROR CONTROL (Optional)
TRANSFER FRAME VERSION NUMBER	SPACECRAF T ID			REPLAY FLAG	RSVD. SPARE	
2 bits	8 bits	6 bits		1 bit	7bits	
2 octets			3 octets	1 octet		2 octets

Figure 5 – Transfer Frame Header

Parts of the Transfer Frame structure are meant to be mission dependant.

For a full specification of the Transfer Frame Layer services, procedures implemented by the service and the Transfer Frame structures, refer to [AD.5] *AOS Space Data Link Protocol.*

3.4 Channel Coding Layer

The Channel Coding Layer provides functions necessary for transferring Transfer Frames over a space link. The functions provided by the Synchronization and Channel Coding Recommendation are:

- Error control encoding and decoding functions,
- Bit transition generation and removal functions,
- Delimiting and synchronizing functions.

The Channel Coding layer receives Transfer Frames and return to the Physical Layer a serial bitstream.

[AD.4] CCSDS TM Synchronization and Channel Coding is the specification that must be used as the recommendation for implementing the Channel Coding Layer of Direct Broadcast Services (LRPT/AHRPT) global specification. [AD.4] provides different synchronization and channel coding techniques and the choice of a particular one is **mission specific**.

3.5 Physical Layer

The physical layer provides the physical channel service. It receives a serial bits stream from the Channel Coding Layer and transforms it into a RF signal.

The Direct Broadcast Services (LRPT/AHRPT) Global specification recommendations for implementing the physical layer are based on [AD.7] CCSDS Radio Frequency and Modulation Systems. Details regarding the main services of the Physical layer are given below.

3.5.1 Modulation

The choice of modulation scheme is **mission specific**.

3.5.2 Frequency

“Typical” frequency ranges used for Direct Broadcast transmissions of LEO satellites are as follows:

1. 137-138 MHz to support Low Rate Transmissions (LRPT).
2. 1698-1710 MHz to support High Rate Transmissions (AHRPT).

3. 7750-7900 MHz to support Very High Rate Transmissions of Meteorological Satellites.
4. 8025-8400 MHz to support Very High Rate Transmissions of Earth Observation Satellites.

These frequency ranges are defined according to [RD.3].

The choice of frequency range is **mission specific** and depends, among other things, on the data rate. It is recommended to select frequencies from point 2 as first option and from points 3 or 4 in cases of higher data rate needs.

3.5.3 Polarisation

Typical polarisation is RHCP, but the choice is **mission specific**.