
**Space data and information transfer
systems — CCSDS Space Link Protocols
over ETSI DVB-S2 Standard**

*Systèmes de transfert des informations et données spatiales —
Protocole pour liaisons spatiales CCSDS utilisant la Norme ETSI DVB-S2*

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Recommendation for Space Data System Standards

CCSDS SPACE LINK PROTOCOLS OVER ETSI DVB-S2 STANDARD

RECOMMENDED STANDARD

CCSDS 131.3-B-1

BLUE BOOK

March 2013

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This document has been approved for publication by the Management Council of the Consultative Committee for Space Data Systems (CCSDS) and represents the consensus technical agreement of the participating CCSDS Member Agencies. The procedure for review and authorization of CCSDS documents is detailed in *Organization and Processes for the Consultative Committee for Space Data Systems*, and the record of Agency participation in the authorization of this document can be obtained from the CCSDS Secretariat at the address below.

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 - The anticipated date of initial operational capability.
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FOREWORD

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- Swedish Space Corporation (SSC)/Sweden.
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1 INTRODUCTION

1.1 BACKGROUND

The high demand in TV broadcasting has pushed the European Telecommunications Standards Institute (ETSI) to define a new satellite communication standard called Digital Video Broadcasting—Satellite—Second Generation (DVB-S2) (reference [1]). This standard is suited to high data rate transmissions, and proposes variable or adaptive coding and modulation with high power and bandwidth efficiencies.

1.2 PURPOSE

The purpose of this document is to define a recommended interface between CCSDS Space Link Protocols (references [3] and [4]) and the DVB-S2 telecom standard (reference [1]), and to recommend options of the DVB-S2 standard suited to high data rate telemetry applications, such as Earth Exploration Satellite Services (EESS) payload telemetry.

1.3 SCOPE

The DVB-S2 standard (reference [1]) proposes advanced modulation techniques (QPSK, 8PSK, 16APSK, and 32APSK) and a wide range of coding rates (from 1/4 to 9/10) with near-Shannon coding schemes (LDPC codes). This high number of modulation and coding schemes allows a wide range of possibilities to satisfy specific mission constraints.

Moreover, to maximize the telemetry system throughput, it appears possible to adapt the transmitted waveform (and the useful data rate) to the variable conditions of the link. The DVB-S2 standard can actually implement Variable Coding and Modulation (VCM) mode, which adapts the transmission scheme to the channel conditions following a predetermined schedule (for example, following a dynamic link budget). When a channel is available to provide feedback (e.g., via a telecommand link), the transmission scheme can be dynamically adjusted using the Adaptive Coding and Modulation (ACM) mode.

The use of the DVB-S2 standard for telemetry makes possible the use of generic Very High Scale Integrated Circuits (VHSIC) Hardware Description Language (VHDL) Intellectual Property (IP) modules for developments. The use of a widely implemented standard simplifies finding transmitting or receiving equipment to check compatibility. Finally, for the ground part, some telecom DVB-S2 receivers or Application Specific Integrated Circuits (ASICs) developed for the telecom market could be reused.

This Recommended Standard is an adaptation profile describing how to use the DVB-S2 standard to transmit CCSDS Transfer Frames for telemetry purpose. The interface between CCSDS and DVB-S2 is based on the Attached Synchronization Marker (ASM) and Channel Access Data Unit (CADU) already introduced in reference [2].

DVB-S2 is used in this adaptation profile as a complete and self-sufficient standard, and definitions and specifications taken from DVB-S2 are applicable only in the context of this Recommended Standard. However, individual DVB-S2 functions or components (e.g., VCM/ACM, 8-PSK, and higher-order modulations) might be reused, redefined, and/or respecified by CCSDS in future Recommended Standards.

1.4 APPLICABILITY

This Recommended Standard applies to the creation of Agency standards and to data communications over space links between CCSDS Agencies in cross-support situations for near Earth Exploration Satellite Services (EESS) payload telemetry. This Recommended Standard includes comprehensive specification of the data formats and procedures for inter-Agency cross support. It is neither a specification of, nor a design for, real systems that may be implemented for existing or future missions.

The Recommended Standard specified in this document is to be invoked through the normal standards programs of each CCSDS Agency and is applicable to those missions for which cross support based on capabilities described in this Recommended Standard is anticipated. Where mandatory capabilities are clearly indicated in sections of this Recommended Standard, it is mandatory to implement them when this document is used as a basis for cross support. Where options are allowed or implied, implementation of these options is subject to specific bilateral cross-support agreements between the Agencies involved.

1.5 DOCUMENT STRUCTURE

Section 1 presents the background, purpose, scope, applicability, and rationale of this Recommended Standard and lists the conventions, definitions, and references used throughout the document.

Section 2 provides an overview of the system architecture.

Section 3 specifies the CADU stream generation.

Section 4 specifies the DVB-S2 transmission of the CADU stream.

Section 5 specifies managed parameters.

Annex A provides the service definition.

Annex B discusses security, Space Assigned Numbers Authority (SANA), and patent considerations.

Annex C lists acronyms and terms used within this document.

Annex D lists MODCOD available in the DVB-S2 standard.

1.6 NOMENCLATURE

1.6.1 NORMATIVE TEXT

The following conventions apply for the normative specifications in this Recommended Standard:

- a) the words 'shall' and 'must' imply a binding and verifiable specification;
- b) the word 'should' implies an optional, but desirable, specification;
- c) the word 'may' implies an optional specification;
- d) the words 'is', 'are', and 'will' imply statements of fact.

NOTE – These conventions do not imply constraints on diction in text that is clearly informative in nature.

1.6.2 INFORMATIVE TEXT

In the normative sections of this document, informative text is set off from the normative specifications either in notes or under one of the following subsection headings:

- Overview;
- Background;
- Rationale;
- Discussion.

1.7 DEFINITIONS AND CONVENTIONS

1.7.1 DEFINITIONS

1.7.1.1 Definitions from the Open System Interconnection (OSI) Basic Reference Model

This Recommended Standard makes use of a number of terms defined in reference [5]. The use of those terms in this Recommended Standard shall be understood in a generic sense, i.e., in the sense that those terms are generally applicable to any of a variety of technologies that provide for the exchange of information between real systems. Those terms are:

- a) Data Link Layer;
- b) Physical Layer;
- c) service;
- d) service data unit.

1.7.1.2 Definitions from OSI Service Definition Conventions

This Recommended Standard makes use of a number of terms defined in reference [6]. The use of those terms in this Recommended Standard shall be understood in a generic sense, i.e., in the sense that those terms are generally applicable to any of a variety of technologies that provide for the exchange of information between real systems. Those terms are:

- a) indication;
- b) primitive;
- c) request;
- d) service provider;
- e) service user.

1.7.1.3 Definition of CADU

The CADU is defined in reference [2]. In this Recommended Standard, CADU only consists in the concatenation of an ASM and a Transfer Frame.

1.7.1.4 Definitions from ETSI DVB-S2 Standard

This Recommended Standard makes use of a number of terms defined in reference [1].

- a) DATAFIELD and DFL are defined in paragraph 5.1.5 of reference [1].
- b) BBHEADER is defined in paragraph 5.1.6 of reference [1].
- c) FECFRAME is defined in paragraph 5.3 of reference [1].
- d) PLFRAME is defined in paragraph 5.5 of reference [1].
- e) Dummy PLFRAME is defined in paragraph 5.5.1 of reference [1].
- f) PLHEADER and MODCOD are defined in paragraph 5.5.2 of reference [1].

1.7.2 CONVENTIONS

In this document, the following convention is used to identify each bit in an N -bit field. The first bit in the field to be transmitted (i.e., the most left justified when drawing a figure) is defined to be 'Bit 0'; the following bit is defined to be 'Bit 1' and so on up to 'Bit $N-1$ '. When the field is used to express a binary value (such as a counter), the Most Significant Bit (MSB) shall be the first transmitted bit of the field, i.e., 'Bit 0' (see figure 1-1).

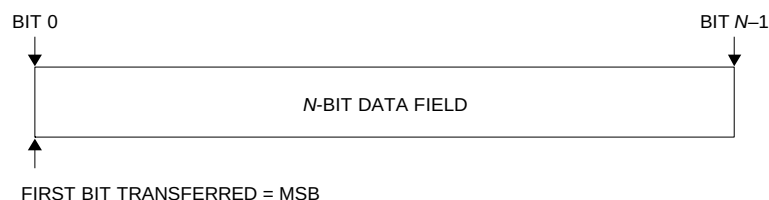


Figure 1-1: Bit Numbering Convention

In accordance with standard data-communications practice, data fields are often grouped into 8-bit 'words' which conform to the above convention. Throughout this Recommended Standard, such an 8-bit word is called an 'octet'.

The numbering for octets within a data structure starts with '0'.

1.8 PATENTED TECHNOLOGIES

The CCSDS draws attention to the fact that it is claimed that compliance with this document may involve the use of patents.

The CCSDS takes no position concerning the evidence, validity, and scope of these patent rights.

The holders of these patent rights have assured the CCSDS that they are willing to negotiate licenses under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statements of the holders of these patent rights are registered with CCSDS. Information can be obtained from the CCSDS Secretariat at the address indicated on page i. Contact information for the holders of these patent rights is provided in annex B.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those identified above. The CCSDS shall not be held responsible for identifying any or all such patent rights.

1.9 REFERENCE DOCUMENTS

The following publications contain provisions which, through reference in this text, constitute provisions of this document. At the time of publication, the editions indicated were valid. All publications are subject to revision, and users of this document are encouraged to investigate the possibility of applying the most recent editions of the publications indicated below. The CCSDS Secretariat maintains a register of currently valid CCSDS publications.

- [1] *Digital Video Broadcasting (DVB); Second Generation Framing Structure, Channel Coding and Modulation Systems for Broadcasting, Interactive Services, News Gathering and other Broadband Satellite Applications*. ETSI EN 302 307 V1.2.1 (2009-08). Sophia-Antipolis: ETSI, 2009.

NOTE – ETSI standards are available for free download at <http://www.etsi.org>.

- [2] *TM Synchronization and Channel Coding*. Recommendation for Space Data System Standards, CCSDS 131.0-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, August 2011.
- [3] *TM Space Data Link Protocol*. Recommendation for Space Data System Standards, CCSDS 132.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.
- [4] *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.
- [5] *Information Technology—Open Systems Interconnection—Basic Reference Model: The Basic Model*. International Standard, ISO/IEC 7498-1:1994. 2nd ed. Geneva: ISO, 1994.
- [6] *Information Technology—Open Systems Interconnection—Basic Reference Model—Conventions for the Definition of OSI Services*. International Standard, ISO/IEC 10731:1994. Geneva: ISO, 1994.

2 OVERVIEW

2.1 ARCHITECTURE

Figure 2-1 illustrates the relationship of this Recommended Standard to the Open Systems Interconnection reference model (reference [5]). Two sublayers of the Data Link Layer are defined for CCSDS space link protocols. The TM and AOS Space Data Link Protocols specified in references [3] and [4], respectively, correspond to the Data Link Protocol Sublayer and provide functions for transferring data using the protocol data unit called the Transfer Frame. The Synchronization and Channel Coding Sublayer provides methods of synchronization and channel coding for transferring Transfer Frames over a space link, while the Physical Layer provides the RF and modulation methods for transferring a stream of bits over a space link in a single direction.

This Recommended Standard covers the functions of both the Synchronization and Channel Coding Sublayer and the Physical Layer.

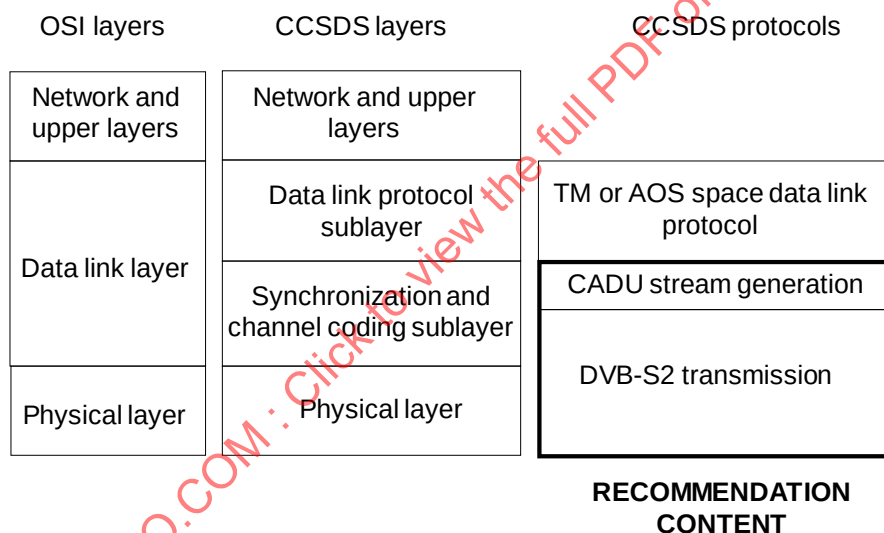


Figure 2-1: Relationship with OSI Layers

2.2 SUMMARY OF FUNCTIONS

2.2.1 GENERAL

This Recommended Standard provides the following functions for transferring Transfer Frames via a stream of bits over a space link:

- a) pseudo-randomizing;
- b) error correction coding and modulation;
- c) Transfer Frame synchronization;
- d) Transfer Frame validation.

2.2.2 PSEUDO-RANDOMIZING

Pseudo-randomizing is specified in the DVB-S2 standard. No other pseudo-randomizing of Transfer Frames is required.

2.2.3 ERROR CORRECTION CODING AND MODULATION

Error correction coding and modulation are specified in the DVB-S2 standard. No other error correction coding of Transfer Frames is required.

2.2.4 TRANSFER FRAME SYNCHRONIZATION

This Recommended Standard specifies an Attached Sync Marker (ASM) for synchronizing Transfer Frames at the receiver.

2.2.5 TRANSFER FRAME VALIDATION

After decoding is performed, the upper layers at the receiving end also need to know whether or not each decoded Transfer Frame can be used as a valid data unit; i.e., an indication of the quality of the received frame is needed. This function is called Frame Validation. In this recommended standard, the Frame Error Control Field defined in references [3] and [4] is used for Transfer Frame Validation at the receiver.

2.3 INTERNAL ORGANIZATION

2.3.1 SENDING END

2.3.1.1 General

Figure 2-2 illustrates the frame structures and stream formats at different stages of processing for the sending end.

2.3.1.2 CADU Stream Generation

This Recommended Standard specifies a method to generate a data stream including CCSDS Transfer Frames received from the layer above by embedding each CCSDS Transfer Frame into a CADU. This method also allows CCSDS Transfer Frame synchronization at the receiver by using an ASM. ASM and CADU are defined in reference [2].

2.3.1.3 DVB-S2 Transmission

This Recommended Standard specifies the DVB-S2 options to transmit the CADU stream.

DVB-S2 functions are not detailed here and the reader must refer to reference [1].

Some important characteristics of the DVB-S2 transmission, as used in this Recommended Standard, are summarized here:

- DVB-S2 transmission is frame oriented: a continuous binary stream to be transmitted is sliced into blocks of Data Field Length (DFL) bits, with DFL depending on the coding rate and the FECFRAME size; Physical Layer frames (PLFRAMEs) are then transmitted continuously on the RF link.
- For a given channel symbol rate, the input (CADU stream) data rate depends on the modulation, the coding rate, the FECFRAME size and the pilot insertion status; the input data rate can be derived from the channel symbol rate using the table in annex D.
- A combination of a modulation and a coding rate is called a MODCOD as per DVB-S2 terminology.

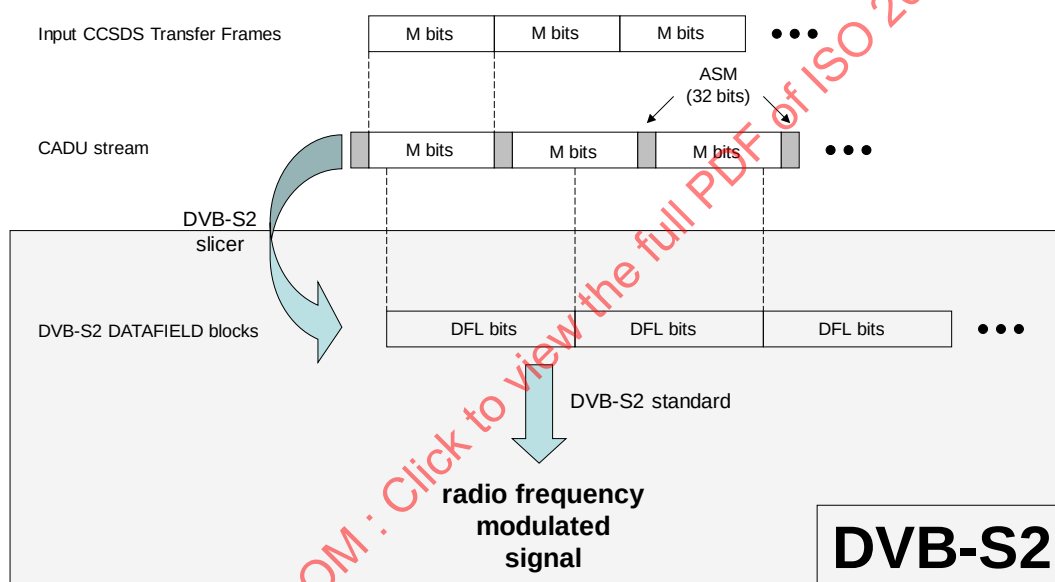


Figure 2-2: Stream Format While Transmitting CCSDS Transfer Frames Using DVB-S2

2.3.2 RECEIVING END

At the receiving end:

- the DVB-S2 demodulator accepts a radio frequency modulated signal and delivers a CADU stream;
- Transfer Frame synchronization allows recovery of CCSDS Transfer Frames in the CADU stream for delivery of those frames to the Data Link Protocol Sublayer.

3 CADU STREAM GENERATION

3.1 OVERVIEW

3.1.1 CCSDS Transfer Frame synchronization is necessary at the receiver. Consequently an ASM is introduced before transmission. Error correction coding and pseudo-randomization are performed at the DVB-S2 transmission level.

3.2 INPUT CCSDS TRANSFER FRAMES

3.2.1 Input Transfer Frames shall be either TM Transfer Frames as specified in reference [3] or AOS Transfer Frames as specified in reference [4].

3.2.2 The Transfer Frames length shall vary between the following minimum and maximum values: 223 octets (1784 bits) and 2048 octets (16384 bits).

3.2.3 Error correction coding and pseudo-randomization shall be performed **only** at the DVB-S2 transmission level.

3.3 CHANNEL ACCESS DATA UNIT

3.3.1 For each Transfer Frame, the system shall construct a CADU containing the ASM and the Transfer Frame.

3.3.2 The ASM shall be the 32-bit (4-octet) marker with value 1ACFFC1D in hex defined in reference [2].

NOTE – In his book, the CADU stream consists of a stream of fixed-length Transfer Frames with each Transfer Frame immediately preceded by an ASM. The ASM attached to a Transfer Frame immediately follows the end of the previous Transfer Frame.

4 DVB-S2 TRANSMISSION

4.1 OVERVIEW

In this section, main characteristics of the DVB-S2 transmission of the CADU stream are specified. Definitions and vocabulary of the DVB-S2 standard (reference [1]) are used.

4.2 DVB-S2 MODE ADAPTATION FORMAT

4.2.1 The RF signal shall conform to the DVB-S2 standard (reference [1]).

4.2.2 The CADU stream shall be transmitted using the single input continuous Generic Stream (GS) mode adaptation format of the DVB-S2 standard (paragraph 5.1 of reference [1]).

NOTES

- 1 No particular alignment between the Transfer Frames of the CADU stream and the DVB-S2 DATAFIELD is needed.
- 2 Following table 3 of reference [1], the first 3 bits of the BBHEADER are consequently '011' ('01': generic continuous stream, '1': single input stream).

4.2.3 The DVB-S2 slicer shall allocate a number of input bits equal to the maximum DVB-S2 DATAFIELD capacity.

NOTES

- 1 In other words, padding (paragraph 5.2.1 of reference [1]) is not used.
- 2 This maximum DATAFIELD capacity is equal to $K_{\text{bch}} - 80$ bits and depends on the considered coding rate and FECFRAME size.
- 3 In the DVB-S2 standard, the channel symbol rate does not change during a transmission; consequently, the required input (CADU stream) data rate changes whenever the MODCOD changes during a transmission.
- 4 When the current MODCOD is modified during transmission using VCM or ACM, the DVB-S2 slicer applies the change without discarding or truncating or impairing the CADU stream, according to the DVB-S2 standard.

4.3 AVERAGE SIGNAL ENERGY

4.3.1 The average channel symbol energy E shall be equal to 1 as defined in paragraphs 5.4.3 and 5.4.4 of reference [1].

4.4 SHAPING FILTERING

4.4.1 The power spectrum density mask in Annex A of reference [1] shall not be applied to the transmitted signal in this Recommended Standard.

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5 MANAGED PARAMETERS

5.1 OVERVIEW

5.1.1 Some parameters associated with coding, synchronization, and modulation are handled by management rather than by inline communications protocol. The managed parameters are generally those which tend to be static for long periods of time, and whose change generally signifies a major reconfiguration of the modulation, synchronization, and channel coding systems associated with a particular mission, i.e., parameters that are fixed within a mission phase. However, as mentioned in annex A, the coding and modulation scheme defined in this book also supports parameters that can be changed from one time interval to the next, within a sequence of time intervals in a mission phase. These two types are referenced in this section respectively as Permanent Managed Parameters and Variable Managed Parameters.

5.1.2 Through the use of a management system, management conveys the required information to the coding, synchronization, and modulation systems.

5.1.3 In this section, the managed parameters used by coding, synchronization and modulation systems are listed. These parameters are defined in an abstract sense and are not intended to imply any particular implementation of a management system.

5.2 PERMANENT MANAGED PARAMETERS

5.2.1 GENERAL

5.2.1.1 All the managed parameters specified in this section shall be fixed for all Transfer Frames on a Physical Channel during a given Mission Phase.

5.2.1.2 The Frame Error Control Field defined in reference [3] or reference [4] shall be present.

NOTE – The Frame Error Control Field is used for Frame Validation as mentioned in 2.2.5.

5.2.2 MANAGED PARAMETERS FOR TRANSFER FRAME SYNCHRONIZATION

The managed parameters for Transfer Frame Synchronization shall be those specified in table 5-1.

Table 5-1: Permanent Managed Parameters for Transfer Frame Synchronization

Managed Parameter	Allowed Values
Transfer Frame Length (octets)	Integer: 223 to 2048 octets

5.2.3 MANAGED PARAMETERS FOR DVB-S2 TRANSMISSION

5.2.3.1 The managed parameters for DVB-S2 transmission shall be those specified in table 5-2.

NOTE – MODCOD, FECFRAME size, and pilot insertion status are variable managed parameters and are indicated with an asterisk in table 5-2.

Table 5-2: Permanent Managed Parameters for DVB-S2 Transmission

Managed Parameter	Allowed Values
Transmission mode	CCM, VCM, or ACM.
Baseband pulse shaping roll-off factor	0.2, 0.25, or 0.35.
Dummy PLFRAME utilization	YES or NO.
Scrambling code number n	Integer: 0 to 262141 (see paragraph 5.5.4 of reference [1]).
Number of MODCOD* supported during a given mission phase	Integer: 1 to 28 (for MODCOD coding, see table 12 paragraph 5.5.2.2 of reference [1]).
List of MODCOD* supported during a given mission phase	List of integers (dimension = 'Number of MODCOD supported during a given mission phase'). Each integer of the list is in the range 1 to 28 and corresponds to a supported MODCOD. (For MODCOD coding, see table 12 paragraph 5.5.2.2 of reference [1].)
Supported FECFRAME size*	Short, Normal, or both.
Supported pilot insertion status*	ON, OFF, or both.

5.3 VARIABLE MANAGED PARAMETERS

The managed parameters specified in table 5-3 shall be fixed on a Physical Channel within one interval of a given Mission Phase.

Table 5-3: Variable Managed Parameters

Managed Parameter	Allowed Values
Current MODCOD	Integer: 1 to 28 (for MODCOD coding, see table 12 paragraph 5.5.2.2 of reference [1]).
Current FECFRAME size	Short or Normal.
Current pilot insertion status	ON or OFF.

NOTE – These variable managed parameters are indicated in the PLHEADER of the transmitted signal; it is consequently not needed to provide them to the receiver working in VCM/ACM mode.

ANNEX A

SERVICE DEFINITION

(NORMATIVE)

A1 OVERVIEW

A1.1 BACKGROUND

This annex provides service definition in the form of primitives, which present an abstract model of the logical exchange of data and control information between the service provider and the service user. The definitions of primitives are independent of specific implementation approaches.

The parameters of the primitives are specified in an abstract sense and specify the information to be made available to the user of the primitives. The way in which a specific implementation makes this information available is not constrained by this specification. In addition to the parameters specified in this annex, an implementation can provide other parameters to the service user (e.g., parameters for controlling the service, monitoring performance, facilitating diagnosis, and so on).

A2 OVERVIEW OF THE SERVICE

A2.1 The present ‘CCSDS Space Link Protocols over ETSI DVB-S2’ Recommended Standard provides unidirectional (one way) transfer of a sequence of fixed-length TM or AOS Transfer Frames at constant frame rate over a Physical Channel across a space link, with optional error detection/correction.

A2.2 The value of the constant frame rate can be changed from one time interval to the next, within a sequence of time intervals in a mission phase. There can be multiple time intervals within a mission phase. This annex does not specify the method for synchronizing the data exchange between the service user and the service provider when there is a change of frame rate: the synchronization is considered to be part of system management and is out of the scope of this annex.

A2.3 Only one user can use this service on a Physical Channel, and Transfer Frames from different users are not multiplexed together within one Physical Channel.