# Use of DVB-S2 ETSI standard in High Data Rate TeleMetry for near space-earth transmissions

## Orange draft Book

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# 1 Background

The requirements of high precision (less than the meter) and quite large field of view (around 20 km) and/or high revisit Earth observation missions (e.g. GMES and METEOSAT 3rd generation) with fast access to the new acquired data (les than two hours) combined with a limited possible number of ground stations are increasing towards Gbit-per-second information transfer speed.
The possible ITU allocated bands for near Earth Exploration Satellites Systems (EESS) remain the same with 8.025/8.4 GHz and 25.5/27 GHz. As use of Ka band introduce some high dependence to ground facilities meteorological conditions especially at low elevations (under 10°), an efficient use of the X band, less affected by those phenomena, is growing of great importance. In parallel, new link margin management considerations are also needed for Ka band to avoid tremendous increase of power only for very low probability cases.
Then, new modulation and coding schemes with high spectral and energy efficiency are needed to better exploit the bandwidth and/or power limited satellite channel. Furthermore, the additional combined use of power margin evolution for Low Earth Orbits and variable effective rate with variable physical layer techniques (VCM = variable Coding and Modulations) brings further impressive average throughput boosts, but also more flexibility requirements to the modem.
The proposed use of the DVB-S2 ETSI standard (see ref /1/) fits with those evolutions as it offers both the effectiveness of variable rate (1/4 up to 8/9) Low Density Parity Check Codes combined with advanced shaping and Amplitude and Phase Shift Keying modulations (Square root Raised Cosine on QPSK, 8PSK, 16APSK up to 32APSK).

# 2 Introduction

DVB-S2 is the second-generation specification for satellite broadcasting – developed by the DVB (Digital Video Broadcasting) Project in 2004. It benefits from more recent developments in channel coding (LDPC codes) combined with a variety of phase and amplitude/phase shift keying modulation formats (QPSK, 8PSK, 16APSK and 32APSK). When used for interactive applications, it may implement Adaptive Coding & Modulation (ACM), thus optimizing the transmission parameters dependant on path conditions. When return channel is not available which corresponds to the High Data Rate TeleMetry case, it may implement Variable Coding & Modulation (VCM).

DVB-S2 is typically used for television/broadcasting by satellite or internet access but it can be used with practically any type of high data rate transmission. DVB-S2 can be used to transmit as well continuous bit-stream as packetised data (MPEG flux essentially).

The purpose of this book is to show the advantages and to describe a way to use DVD-S2 in TM space-earth transmissions. For that reason, we focus only on a subset of the complete ETSI standard (see ref0[1]). We will then consider only the DVB-S2 standard in continuous Generic Stream mode with a short FECFRAME length (16200 coded bits). Generic Stream mode with a long FECFRAME length (64800 coded bits) could also be used at the expense of more hardware complexity.
The general aim is to be able to use generic Intellectual Property (IP) for the on-board development but also to deal at the ground side with a standard DVB-S2 receiver without

custom precise modifications. For that reason, the global layering could seem to be quite overcharged but it corresponds to the price for leaving completely generic.

# 3 Concept of the packetised Generic Stream transmission in DVB-S2 ETSI standard

## *3.1 Architecture*

Figure 1 illustrates the relationship of the DVB-S2 ETSI standard to the Open Systems Interconnection (OSI) reference model (reference [5]). DVB-S2 ETSI standard corresponds to the two lowest OSI layers, i.e. the data link layer and the physical layer. In parallel, the CCSDS layers specific subdivision is also detailed.

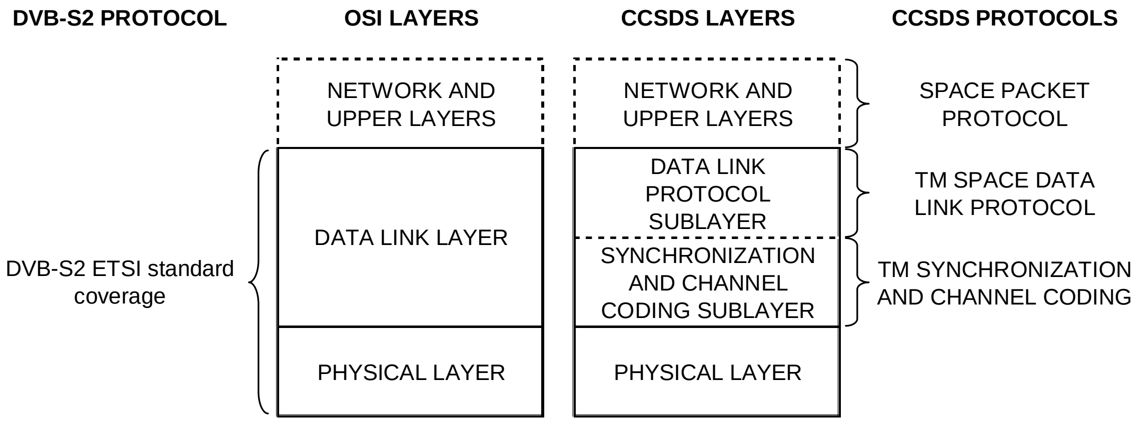


**Figure 1 - Relationship with OSI Layers**

The functional block diagram of the DVB-S2 standard for a packet stream transmission is given by Figure 2. We can divide this scheme in three main blocks:

- o Mode and stream adaptation
- o Forward Error Control Encoding
- o Physical Layer Frame and Modulation

The mode and stream adaptation block provides buffering, signaling and scrambling functions for transferring data using the protocol data unit called the BaseBand Frame (BBFRAME). The signaling correspond to a header insertion so as to delimit physical containers. The scrambling is for independence to the data contents ensuring sufficient transitions ('0' to '1' and reverse) and bit equiprobability. This block belongs to the data link layer of the OSI. Its function is equivalent to the CCSDS transfer framing with buffering preceded by the ASM concatenation and also the scrambling of the CCSDS actual "TM and synchronization channel coding" Blue Book (ref 0[4]) but is mapped to the specific DVB-S2 frame size. As far as DVB-S2 is rather concerned by MPEG packet stream transmission, it allows also a Generic Continuous Stream transmission which is the selected mode in this document. This option of the ETSI standard can work efficiently with CCSDS non coded Transfer Frame transmission.

The Forward Error Control encoding provides near Shannon limit error protection when associated with Belief propagation iterative decoding. The combined use of Irregular Repeat and Accumulate Low Density Parity Check Code (IRA-LDPCC) as inner code and Bose-Chaudhuri-Hocquenghem (BCH) bloc code as outer code is for compensation of low error cycles in LDPCC and permits to avoid Error rate flattening. A wide range of coding rates is possible in the ETSI standard but we suggest to limit the number of possibilities. In DVB-S2 ETSI standard, two size of coded bits BBFRAME called "FECFRAME" are possible: 64800 bits (normal FECFRAME) or 16200 bits (short FECFRAME). For CCSDS use, only the short one (equivalent in size with the actual possible coded Transfer Frame size especially the one with CCSDS interleaver size I = 8) may be used. In fact, use of the short FECFRAME allows to limit the buffer size thus limiting the need of additional memory on board and permits more speed efficient parallel decoding at the receiver side. It should be noted that for very high rate data telemetry, due to this limited size of frame, specific attention should be paid when transmitting null contents frame for fulfilling the ITU regulations. This block belongs to the data link layer.

The Physical Layer Frame (PLFRAME) is obtained when mapping the coded bits of the FECFRAME with a specific header (PLHEADER) and optional pilots symbols distributed along the frame giving then a XFECFRAME. For robustness purpose, this PLHEADER and those pilot symbols are scrambled and modulated with a very robust scheme (BPSK for PLHeader and 1PSK for pilot symbols) so as to help the demodulator for low SNR. This physical scrambling is for energy dispersal and avoid repetitive contents. Obtained by a set of Gold sequences, this scrambling lasts all the PLFRAME. The content of the PLHEADER allows to identify the Start of PLFRAME but also the chosen coding and modulation (defined at the frame level), the length of the frame (normal or short) and the use of pilot symbols or not. Due to its importance, this PLHEADER is strongly protected by a Reed-Muller derived bi-orthogonal (64,7) code. Finally, a bit interleaver (for modulations above QPSK) and a shaped (SRC) modulation transforms the message in order to be transmitted by the medium. Additionally, at this level, when no data are present at the interface, the equipment still operating can insert dummy frames so as to continue frame transmission. Those specific dummy frames can easily be suppressed at the receiver side without any ambiguity. All those processes belong to the physical layer.

It can be noticed that this orange draft book focused only on a limited set of the DVB-S2 standard capacity but never proposed modifications on that standard so as to allow the use of standardized equipment. Especially at the physical layer, we have choose to remove the 32APSK modulation among the possible as it's usage seems far more adapted to multiple carrier in a channel usage that is far from our high data rate telemetry focus.

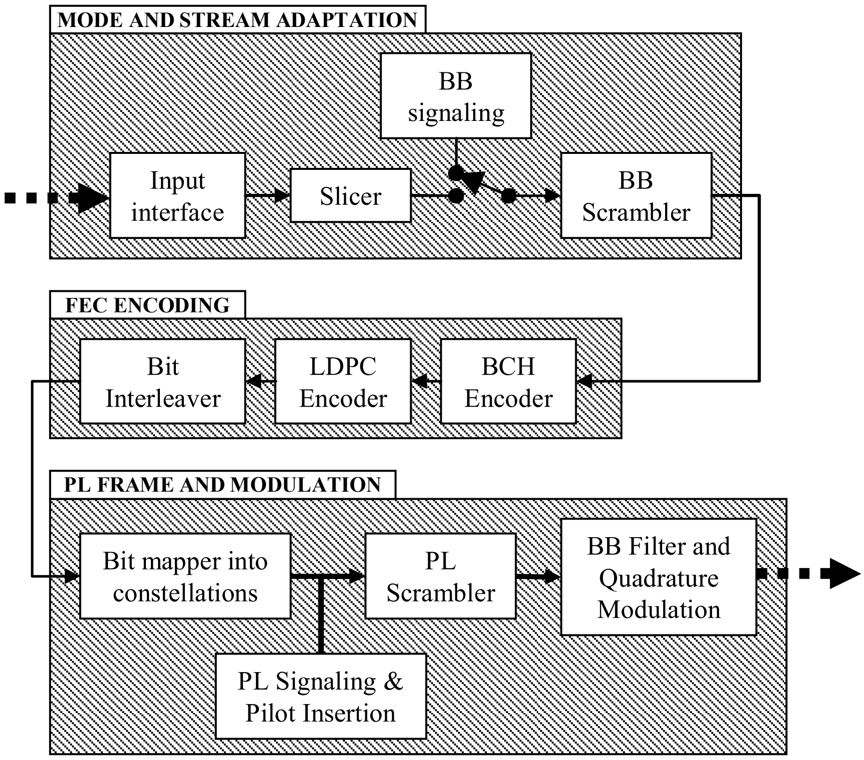


**Figure 2 - Functional block diagram of the DVB-S2 System**

## 3.2 Mode and stream adaptation

## 3.3 Input interface

As said above, the DVB-S2 protocol allows the Generic Stream transmission mode as an option for professional services (see p15 in ref [1]). A Generic Stream shall be characterized by a continuous bit-stream or a packetised stream of constant-length User Packets (UP), with length UPL bits (maximum UPL value 64 Kbits). As the packetised mode suppose use of specific packet synchronization and CRC calculation, we prefer to focus on a continuous input generic stream mode.

### 3.3.1 Slicer

According to the Figure 3, the Slicer input stream is organized to "slice" a generic continuous stream in successive frames. Thus, the Slicer shall read (i.e. slice) from its input (single input stream) a DATA FIELD, composed of DFL bits (Data Field Length), where:

$$k_{bch} \text{ - (10 bytes)} \geq \text{DFL} \geq 0 \text{ [1]}$$

A DATA FIELD shall be composed of bits taken from a single input port and shall be transmitted in a homogeneous transmission mode (FEC code and modulation).

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[1] $k_{bch}$ as per [Table 1], 80 bits are dedicated to the BBHEADER, see clause 3.3.2

In our case, the Slicer shall allocate a number of input bits equal to the maximum DATAFIELD capacity (DFL= $k_{bch}$ -80) in a buffer, thus breaking the continuous stream in subsequent DATAFIELDs.

When a DATA FIELD is not available at the slicer request on the input port, the physical Layer Framing subsystem shall generate and transmit a DUMMY PLFRAME. This process is of particular interest for CCSDS as it allows the TM transmitter to automatically fill so as to get full continuous transmission without being obliged to go at the CCSDS transfer frame level (problem of Virtual Channels and counters to increment).

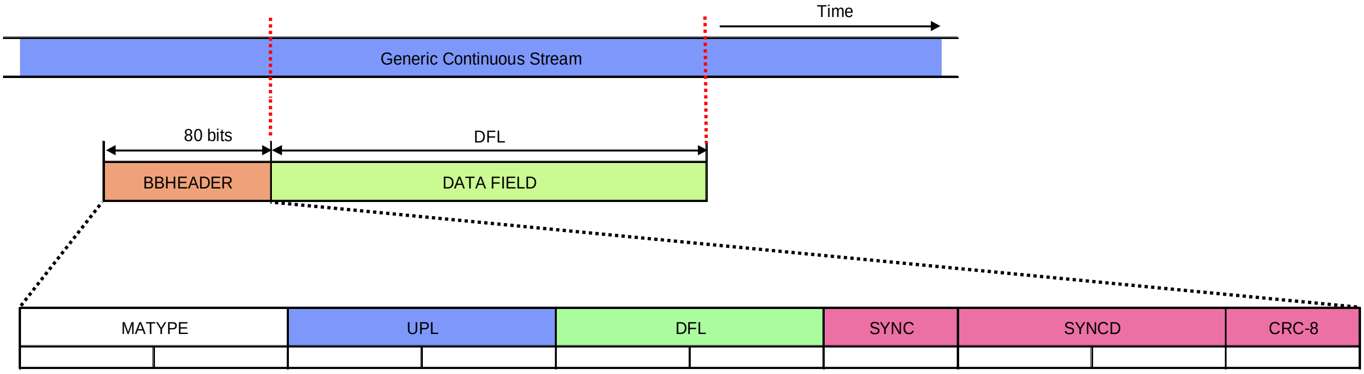


**Figure 3 - Stream format at the output of the Mode Adapter**

### 3.3.2 Base-Band Header insertion

A fixed length base-band Header (BBHEADER) of 10 bytes shall be inserted in front of the DATA FIELD, describing its format. It's complete description is rather long and a lot of fields are not used in Generic continuous stream mode.

First byte (MATYPE-1):
- TS/GS field (2 bits): Transport Stream Input or Generic Stream Input (packetised or continuous)
- SIS/MIS field (1 bit): Single Input Stream or Multiple Input Stream
- CCM/ACM field (1 bit): Constant Coding and Modulation or Adaptive Coding and Modulation (VCM is signaled as ACM)
- ISSYI (1 bit), (Input Stream Synchronization Indicator): Not active in our case.
- NPD (1 bit): Null-packet deletion active/not active. Always non active in our case.
- RO (2 bits): Transmission Roll-off factor ($\alpha$). Three values are possible among 0.35, 0.25 and 0.2. As a compromise between crest factor and length of impulse response and also spectral sharpness, we propose to use a 0.25 roll-off factor value.

Second byte (MATYPE-2):
- If SIS/MIS= Multiple Input Stream, then second byte=Input Stream Identifier (ISI); else second byte reserved

UPL (2 bytes): User Packet Length in bits, in the range [0,65535].

DFL (2 bytes): Data Field Length in bits, in the range [0,58112]. It introduce a link to the chosen code rate. For example, use of the 2/5 code implies a DFL = 6312 (decimal) or 18A8 (hexadecimal)

SYNC (1 byte): copy of the User Packet Sync-byte, not used in generic continuous stream mode

SYNCD (2 bytes): distance in bits from the beginning of the DATA FIELD and the first UserPacket from this frame (first bit of the CRC-8). SYNCD=65535 (decimal) means that no UserPacket starts in the DATA FIELD. Even if there remain some ambiguity, we suggest to use this value in the generic continuous stream mode.

CRC-8 (1 byte): error detection code applied to the first 9 bytes of the BBHEADER. The encoding circuitry is given in the figure hereunder corresponding to ad the remainder of the polynomial division of the product $X^8$. u(X) by G(X), u(X) being the 72 bits of the first 9 bytes of the BBHEADER and G(X) being the generator polynomial.

$$G(X) = (X^5+X^4+X^3+X^2+1)(X^2+X+1)(X+1) = X^8+X^7+X^6+X^4+X^2+1$$

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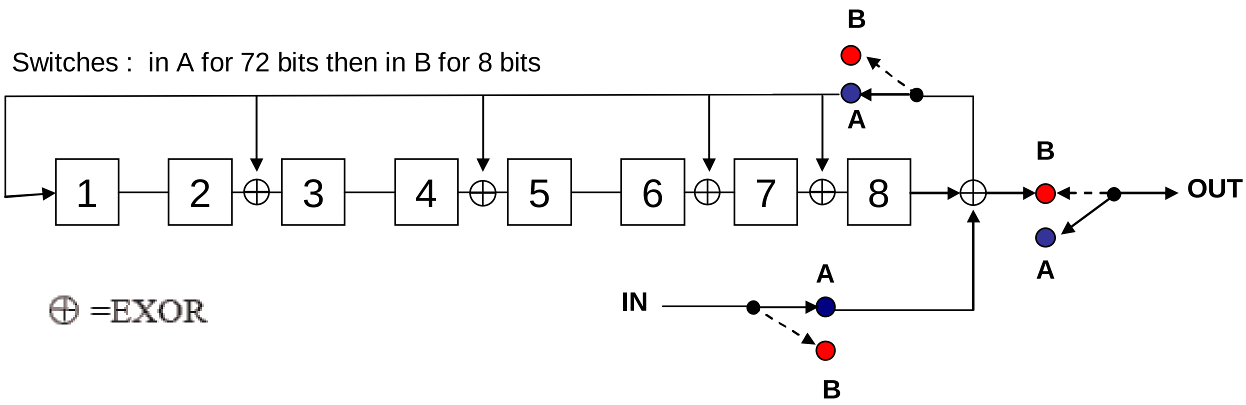



The BBHEADER transmission order is from the MSB of the TS/GS field.
So for the Generic continuous stream mode, this BBHEADER becomes (in hexadecimal, Most Significant Value first an X representing an undefined content and Y a specific variable content) :

61 XX 00 00 YY YY XX FF FF YY

## 3.4 FEC encoding

The FEC encoding shall perform Outer Coding (BCH), Inner Coding (LDPC) and Bit Interleaving for high efficiency modulations (8PSK and 16APSK). The input stream shall be composed of BBFRAMEs and the output stream of FECFRAMEs. Each BBFRAME ($k_{bch}$ bits) shall be processed by the FEC coding subsystem, to generate a FECFRAME ($n_{ldpc}$ bits).

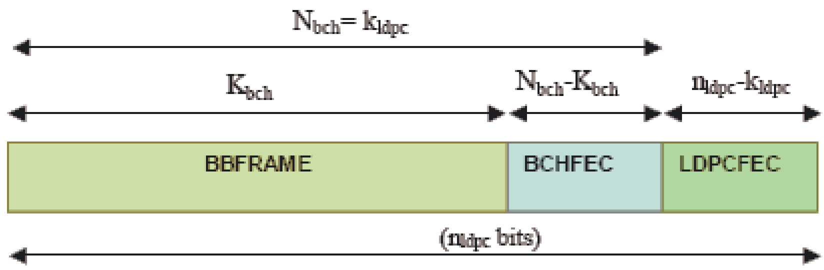



**Figure 4 – Format of data before interleaving**

Table 1 gives the FEC coding parameters for our selected code rates for the short FECFRAME ($n_{ldpc}$=16 200 bits). We have suppressed the rates 1/4 (which is rather a 1/5 for short frames), 1/3 and 1/2 as they offer quite limited performances in Eb/No compared to the 2/5 case. Furthermore, those code rates are only use for QPSK and as far as they correspond to very low efficiencies (near spread spectrum), we have considered their suppression as a potential hardware gain at the transmitter (on board) side.
For short frames, the BCH outer code is always working with a correcting capability t = 12.

All the precise information for BCH and LDPC check bits elaboration are described precisely in the standard ref [1] from p 23 to p 26. For that reason and as far as they are proprietary ETSI information we will not reproduce them in this document. We remind that the ETSI standards are available for free download at http://www.etsi.org

The role of the bit interleaver is to allow to produce very easily bit metrics from the symbol's one obtained at the receiver for easy soft decoding. The principle is a very classic column-row interleaver with a bit serial written in column (size from 3 to 4 bits depending on modulation order) and a bit serial read in row (size 5400 or 4050 bits depending also on modulation order). For more details, see ref [1] p25 and 26.

## *3.5 Physical Layer (PL) Framing*

First, a bit mapping associate the bit interleaved FECFRAME to the set of modulations supported by the DVB-S2 ETSI standard (QPSK, 8PSK, 16APSK) with for each an absolute (not differential) and conventional Gray-coded mapping. Particularly, the QPSK mapping is fully compatible with the recent CCSDS definition (§2.4.10 of the ref [6]). As explained before, we will not detail the precise mapping including radius values for APSK modulations as far as they are fully defined in ref [1] from pages 26 to 29.

The PLFraming shall then generate a physical layer frame (named PLFRAME), this frame being defined at the constellation symbol level. It does a XFECFRAME slicing into an integer number S of constant length SLOTs (length: M=90 symbols each); S value shall be taken according to Table 2. All those S slots use the same modulation and coding.

So as to identify each PLFRAME beginning, a PLHEADER is added to the XFECFRAME but with a specific modulation, $\pi$/2-BPSK, and coding, bi-orthogonal (64,7), so as to be very robust to the worse possible receive conditions. This PLHEADER contains specific information for receiver configuration. PLHEADER shall occupy exactly one SLOT (length: M=90 Symbols).

To help receiver synchronization and tracking for low SNR with respect to modulation order, it is possible to insert Pilot Block every 16 SLOTS,. The Pilot Block shall be composed of P=36 pilot symbols of unmodulated carrier (1PSK with I = 1/√2, Q = 1/√2).

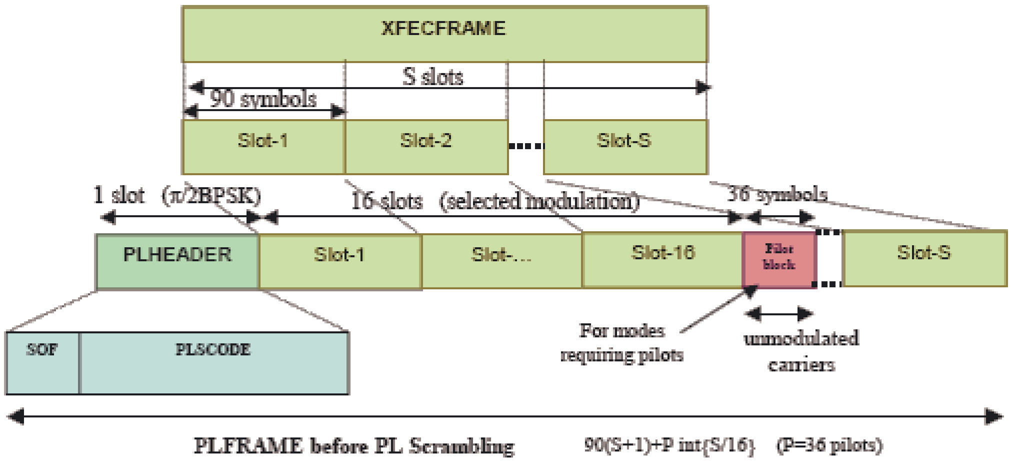



**Figure 5 – Format of a “Physical Layer Frame” PLFRAME**

### 3.5.1 PL signaling

The PL signaling shall insert a PLHEADER before each XFECFRAME. PLHEADER is use d at the receiver side for synchronization and physical layer signaling.

The PLHEADER shall be composed of the following fields:

SOF (26 symbols), identifying the Start of Frame is corresponds to the sequence 18D2E82 (in hexadecimal)

PLS (64 symbols), shall be a non-systematic binary code of length 64 and dimension 7. It transmits 7 bits for physical layer signaling purpose:

- MODCOD: (5 symbols) identifying the XFECFRAME modulation and FEC rate.
- TYPE (2 symbols), identifying length (normal or short FECFRAME) and the presence or not of pilots

Possible values for these fields are given in ref [1] page 31 the PLFRAME constitution. The MODCOD field and the MSB of the TYPE fields are bi-orthogonally coded with a code (64,7) derived from a Reed-Muller (32,6) code. As described in Figure 6 LSB of the TYPE field determines if each odd bit in the code is either equal to the previous one or is always the opposite. This code allows to protect the PL signaling data down to -2 dB of channel SNR which leave good margin for QPSK modulation even with our ultimate 2/5 code rate.

The generator matrix of the linear block code is given in ref [1] page 32

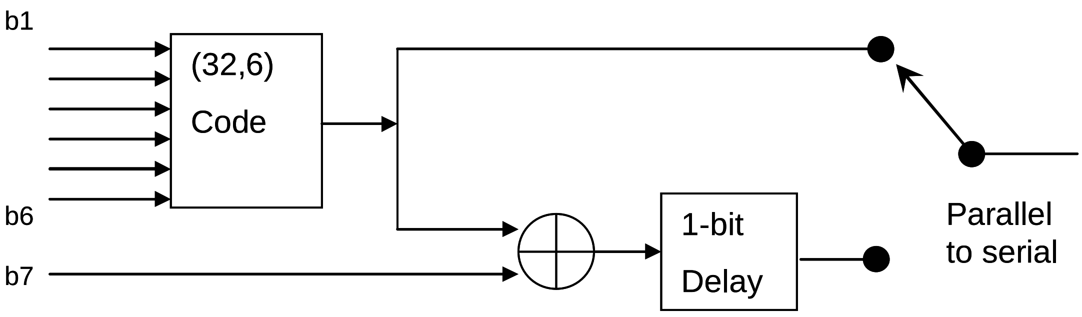



**Figure 6 - PLS code**

### 3.5.2 Physical layer scrambling

Before the modulation, each PLFRAME, excluding the PLHEADER, shall be randomized for energy dispersal. The scrambling code sequences is a complex sequence ($C_I$ $+jC_Q$) constructed by combining two real m-sequences (generated by means of two polynomials of degree 18). The resulting sequence are segments of a set of Gold sequences (more detailed information about the generation of this sequences is given in ref [1] from pages 33 to 34).

The length of the sequence used has a period greater than the PLFRAME maximum required duration in order to avoid the spurious formation due to the sequence periodicity. The sequence, will be then truncated to the current PLFRAME length and reinitialized at the end of each PLHEADER.

# 4 Coding efficiency and modulation performances

## *4.1 Coding efficiency*

DVB-S2 transmission efficiency is given by three coding phases, The BBFRAME forming, the FEC Encoding and the PL Framing.

The BBFRAME efficiency depends on the frame length ($k_{bch}$). The chosen among the possible values for $k_{bch}$ are given by the Table 1. The BBFRAME efficiency is then defined by: $\eta_1 = (k_{bch}-80)/\ k_{bch}$ .

The subsequent FEC Encoding efficiency is also depending on the $k_{bch}$ length. Table 2 shows the BBFRAME efficiency, FEC Encoding efficiency and the combination of both for all the possible values of $k_{bch}$. The FEC Encoding efficiency is $\eta_2 = k_{bch}/n_{ldpc}$ .

| LDPC Code Id. | BCH Uncoded Clock $k_{bch}$ | BCH Coded Block LDPC Uncoded Block $k_{ldpc}$ | BCH t-error correction | Effective LDPC Rate | LDPC Coded Block $n_{ldpc}$ | BBFRAME efficiency | FEC Encoding efficiency | BBFRAME + FEC Encoding efficiency |
|---|---|---|---|---|---|---|---|---|
| 2/5 | 6312 | 6480 | 12 | 2/5 | 16200 | 98.73% | 38.96% | **38.47%** |
| 3/5 | 9552 | 9720 | 12 | 3/5 | 16200 | 99.16% | 58.96% | **58.47%** |
| 2/3 | 10632 | 10800 | 12 | 2/3 | 16200 | 99.25% | 65.63% | **65.14%** |
| 3/4 | 11712 | 11880 | 12 | 11/15 | 16200 | 99.32% | 72.30% | **71.80%** |
| 4/5 | 12432 | 12600 | 12 | 7/9 | 16200 | 99.36% | 76.74% | **76.25%** |
| 5/6 | 13152 | 13320 | 12 | 37/45 | 16200 | 99.39% | 81.19% | **80.69%** |
| 8/9 | 14232 | 14400 | 12 | 8/9 | 16200 | 99.44% | 87.85% | **87.36%** |

**Table 1 – Coding parameters (for short FECFRAME $n_{ldpc}$ = 16200)**

The PL Framing efficiency depends on the modulation used. Values for both cases, with and without pilots, are given by Table 2.

| ηmod | S | η pilot | η no-pilot |
|---|---|---|---|
| 2 | 360 | 97.35% | 99.72% |
| 3 | 240 | 97.32% | 99.59% |
| 4 | 180 | 97.09% | 99.45% |

**Table 2 – S=number of SLOTs (M=90 symbols) per XFECFRAME**

The PLFRAMING efficiency is $\eta_3$= 90S / [90(S+1)+ P int{(S-1)/16}], where P=36 and int{.} is the integer function.

Then the global efficiency can be obtained $\eta = \eta_1 \bullet \eta_2 \bullet \eta_3$

## 4.2 Performance

Table 3 summarizes performance requirements at QEF over AWGN. Quasi Error Free can be assumed equivalent to a mean BER value of $10^{-9}$ after complete forward error correction (LDPC and BCH). It must be noticed that due to BCH protection, a lot of error patterns correspond to a 13 bits error in the frame.

| Mode | Spectral efficiency pilots | Spectral efficiency no-pilots | Ideal Es/N0 (dB) for DECFRAME legth=16200 | ideal Eb/No (dB) pilots | ideal Eb/No (dB) no-pilots |
|---|---|---|---|---|---|
| QPSK 2/5 | 0.744564 | 0.760928 | -0.1 | **1.18** | 1.09 |
| QPSK 3/5 | 1.131661 | 1.156532 | 2.43 | **1.89** | 1.80 |
| QPSK 2/3 | 1.260693 | 1.288400 | 3.3 | 2.29 | **2.20** |
| QPSK 3/4 | 1.389725 | 1.420269 | 4.23 | 2.80 | **2.71** |
| QPSK 4/5 | 1.475747 | 1.508181 | 4.88 | 3.19 | **3.10** |
| QPSK 5/6 | 1.561768 | 1.596093 | 5.38 | 3.44 | **3.35** |
| QPSK 8/9 | 1.690800 | 1.727961 | 6.4 | 4.12 | **4.02** |
| 8PSK 3/5 | 1.692033 | 1.725319 | 5.7 | **3.42** | 3.33 |
| 8PSK 2/3 | 1.884959 | 1.922040 | 6.82 | **4.07** | 3.98 |
| 8PSK 3/4 | 2.077885 | 2.118761 | 8.11 | 4.93 | **4.85** |
| 8PSK 5/6 | 2.335120 | 2.381056 | 9.55 | 5.87 | **5.78** |
| 8PSK 8/9 | 2.528046 | 2.577778 | 10.89 | 6.86 | **6.78** |

| | | | | | |
|---|---|---|---|---|---|
| 16APSK 2/3 | 2.505223 | 2.548792 | 9.17 | **5.18** | 5.11 |
| 16APSK 3/4 | 2.761633 | 2.809662 | 10.41 | **6.00** | 5.92 |
| 16APSK 4/5 | 2.932574 | 2.983575 | 11.23 | 6.56 | **6.48** |
| 16APSK 5/6 | 3.103514 | 3.157488 | 11.81 | 6.89 | **6.82** |
| 16APSK 8/9 | 3.359924 | 3.418357 | 13.09 | 7.83 | **7.75** |

**Table 3 – $E_s/N_0$ performance at Quasi Error Free BER=$10^{-9}$ (AWGN channel)**

# 5 Telemetry Space Data Link Protocol over DVB-S2

Since DVB-S2 allows a Continuous Generic Stream input, the transmission of Transfer Frames (reference [3]) over DVB-S2 is possible. Figure 1 illustrates the relationship of the Telemetry Space Data Link Protocol to the Open Systems Interconnection reference model (reference [5]).

TM Space Data link protocol corresponds to the data link layer in the OSI model. The CCSDS model has divided this layer in two sublayers, the data link protocol sublayer end the synchronization and channel coding sublayer. In this model the TM Space Data link protocol corresponds to the data link protocol sublayer.

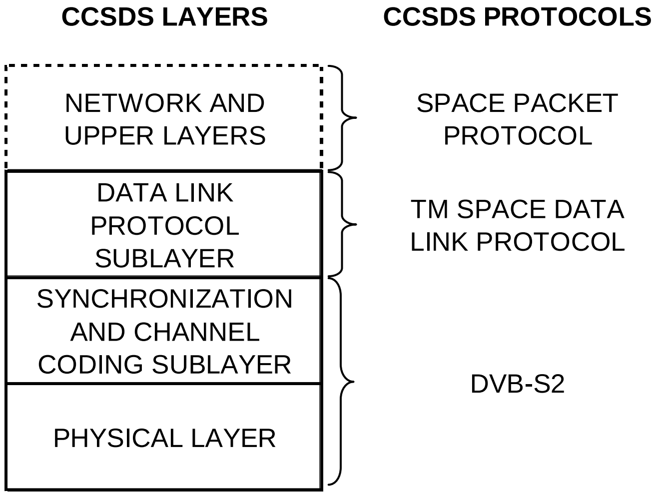
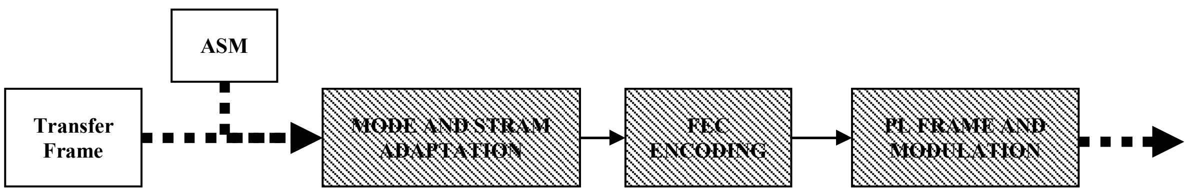


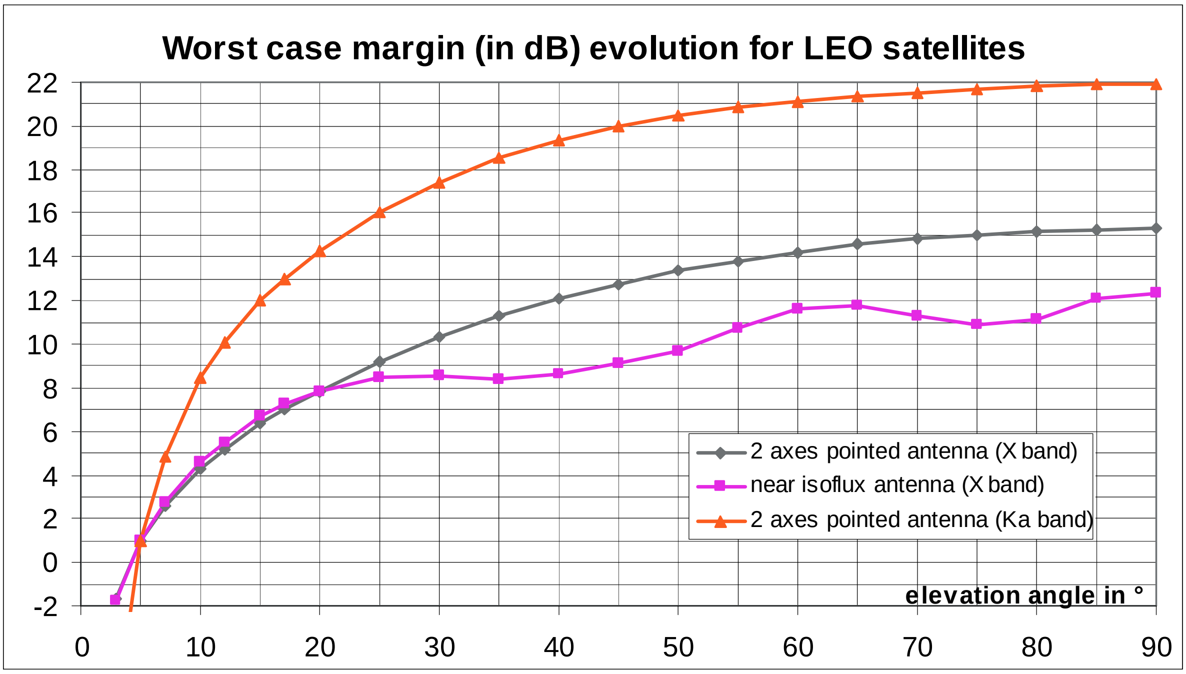

**Figure 7 - Telemetry Space Data Link Protocol over DVD-S2**

According to the CCSDS layers model, the transmission of Transfer Frames over the DVB-S2 standard is represented by Figure 7. Synchronization of the Transfer Frame is achieved by using a stream with fixed length Transfer Frames with an Attached Sync Marker (ASM) between them (the concatenation being called a CADU). The ASM will be inserted as described in reference [4] for an **uncoded** transfer frame (non Reed-Solomon coded or non turbo coded TF). The DVB-S2 standard will then allow to transmit the concatenation of Transfer Frame with a 6 byte header (Transfer Frame Header) with the ASM called a Channel Access Data Unit (CADU). We emphasize on the fact that the use of the CCSDS optional Frame Error Control Field of 2 bytes (CRC16) inside the CADU remains interesting, as the DVB-S2 BCH outer code is used with a limited to 12 bits error correction and detection capability on more than 6,3 kbits.



# 6 Advantages of the VCM use

We give in the figure below the typical evolution of the margin with respect to ground elevation for LEO Earth Observation satellites at around 700 km. It can be seen that only the low elevation case is predominant so all the margin at highest elevation can be used for a change in coding & modulation so as to increase the bit rate (without changing the Baud rate to keep the spectral occupation constant). This property is particularly evident in Ka band as far as those margin are calculated for a worst case with very few (around 1%) unavailability due to propagation (rain, clouds,…)



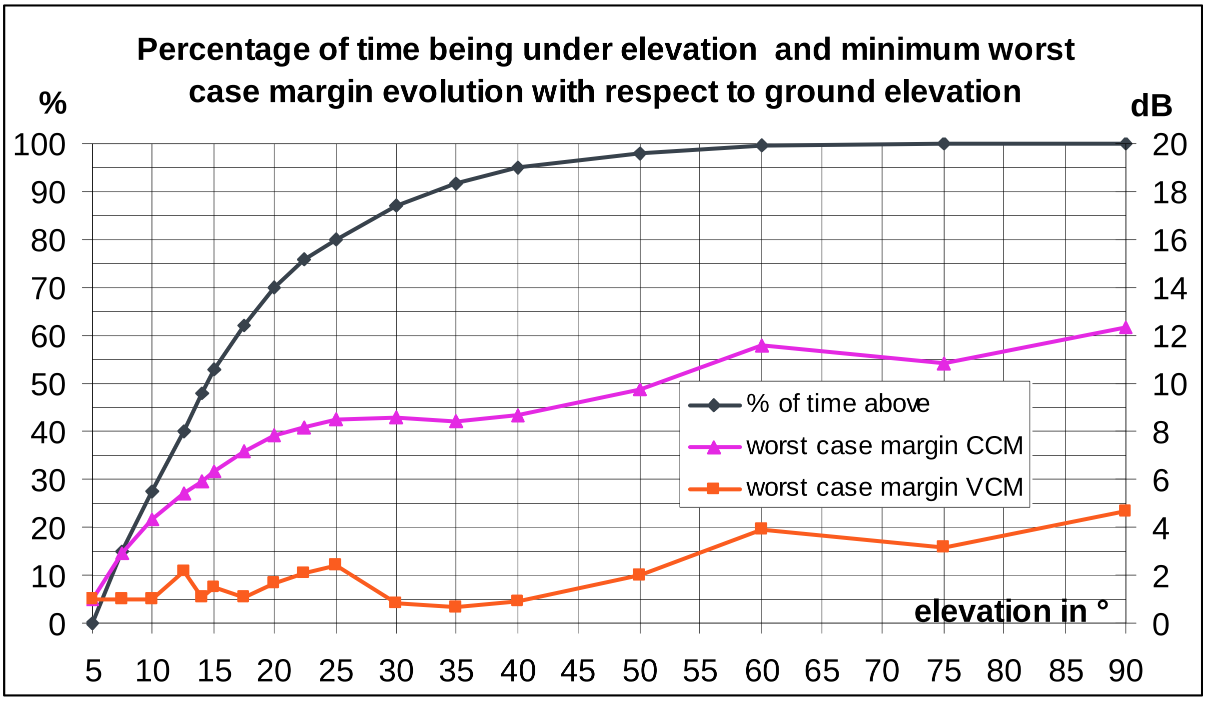

Taking into account that for LEO satellites between 600 and 850 km altitude and by averaging among several passes above mid-latitude (between 35 and 55 ° latitude) ground stations, it is possible to obtain durations and then a percentage of time of being under a given elevation angle. For more higher latitude stations, this time distribution is a bit different but the same reasoning still behaves. By considering the worst case margin evolution, and by using this percentage, it is then possible to show the benefits of a VCM strategy.

Let's assume a **100 MBauds HDRTM link** as far as it is an actual high value for having all digital Matched Filtering and emitting and receiving processing. By using VCM capabilities of DVB-S2, it is then possible to make some choice among the possible couple of coding/modulations so as to keep a global worst case margin around 1 dB. If we were using only **GMSK** with LDPC code of **rate 5/6** (CCM like), our margin will be ever growing far above 1 dB but the mean global transmitted rate will be 100*5/6 = **83.5 Mb/s**. If we consider a **DVB-S2 VCM** possible scheme, we could obtain a mean global transmitted rate of 15*1.654+12.5*1.98+20.3*2.228+14.2*2.478+25*2.966+13*3.3 = **247 Mb/s**.

The possible choice are synthetized in the following table (worst case for implementation value):

| DVB-S2 coding/modulation | QPSK 5/6 | 8PSK 2/3 | 8PSK 3/4 | 8PSK 5/6 | 16APSK 3/4 | 16 APSK 5/6 |
|---|---|---|---|---|---|---|
| efficiency (bit/channel_symbol) | 1,654 | 1,98 | 2,228 | 2,478 | 2,966 | 3,3 |
| Es/No for 10^-7 PER | 5,2 | 6,7 | 8 | 9,4 | 10,3 | 11,7 |
| implementation losses | 1,5 | 1,9 | 2 | 2,1 | 2,5 | 2,7 |
| overall Es/No | 6,7 | 8,6 | 10 | 11,5 | 12,8 | 14,4 |
| delta Es/No or Power | 0,0 | 1,9 | 3,3 | 4,8 | 6,1 | 7,7 |
| delta margin | 0,0 | 1,9 | 3,3 | 4,9 | 6,1 | 7,4 |
| percentage of being in this choice | 15,0 | 12,5 | 20,3 | 14,2 | 25,0 | 13,0 |
| elevation class | 5 to 7,5° | 7,5 to 10° | 10 to 14° | 14 to 17,5° | 17,5°to 30° | 30 to 90° |

The global comparison can be summarized in the following figure :




This calculation shows that use of DVB-S2 VCM capabilities could offer a near 2.5 bit/channel_symbol efficiency instead of a less than 0.85 bit/channel_symbol allowed by GMSK signalling.
This huge expense of efficiency is of great interest for sharing X and Ka band resources.

The VCM capability of the DVB-S2 standard allows to operate very easily for high data rate telemetry just asking the transmitter by the way of a limited set of TC bits to change the emitted scheme, those TC bits being elaborated from the On Board Computer (or a Payload Computer) from an operating plan, the orbit characteristics can be forecasted on a several day basis without being critic for the VCM change time. The internal data flux control allows also to regulate the change in effective data rate. It should be noted that this proposed practice represent an evolution for operations but it must be considered that the use of a pointing antenna corresponds to far more complex commands and usage….

# 7 References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