

# Space Link Services Area

## Resolution SLS-R-2018-03-003

### Color change from Magenta to Blue for “Variable Coded Modulation Protocol”

### CCSDS 431.1 Book

**27<sup>th</sup> March 2018**

**The Space Link Services Area,**

**CONSIDERING** that the RF & Modulation (RFM) Working Group and the Coding & Synchronization (C&S) Working Group

- are currently working on a draft Magenta Book on the Variable Coded Modulation (VCM) Protocol for which, a number of additions become necessary in order to comply to conditions risen at CESG Poll and those additions address e.g.
  - increased number of definitions of coding schemes (from CCSDS 131.0-B) available for VCM,
  - more detailed description of the pilot structure,
  - application of those pilots to coding schemes (from 131.0-B) not previously considered/studied for VCM
  - etc.

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- agree that these changes introduce Blue Book material changing the intended nature of the Magenta Book
- had consensus to request modification of the approved CWE Project for “Variable Coded Modulation Protocol” to become a project for Blue Book

**CONSIDERING** also that

- a related approved CWE Project for Magenta Book is available at <https://cwe.ccsds.org/fm/Lists/Projects/DispFormDraft.aspx?ID=398>
- an updated concept paper is available and here attached,
- the updated concept paper addresses the delta required for a Blue Book (e.g. prototypes), and
- appropriate resources have been identified.

**RESOLVES** to request CMC to approve the modification of the approved CWE Project for “Variable Coded Modulation Protocol” to become a project for Blue Book, and

**RECOMMENDS** that CMC approve this resolution and, finally

**REQUESTS** that a CMC poll be conducted to accomplish this.

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## Variable Coded Modulation (VCM) Protocol Blue Book

### Concept Paper

March 27, 2018

#### 1) Introduction

Variable Coded Modulation (VCM) is a method to rapidly switch the channel coding and modulation used during a communications session. After a transmission using one coded modulation, another coded modulation may be used to match dynamic link conditions in near real time. With judicious choice of the coded modulations over time, excess margin can be reduced and total data throughput increased. Such dynamic conditions may arise, for example, because of changes in geometry, weather, interference, launch plumes, and scintillation.

#### 2) Purpose

The purpose of this concept paper is to propose that the Coding and Synchronization Working Group (CS WG) and the RF Modulation Working Group (RFM WG) consider a variable coded modulation (VCM) protocol for inclusion as a Recommended Standard, i.e., Blue Book.

CCSDS has defined a VCM protocol for use with the CCSDS SCCC codes [2] and with the DVB-S2 BCH/LDPC codes [3, 5]. The new Blue Book will define a VCM protocol for use with the CCSDS TM turbo and LDPC codes [1]. The protocol will be compatible with the existing VCM protocols described in [2] and [5], which are nearly, but not quite identical. The book will be compatible with the existing CCSDS VCM protocols, while extending it for use with a subset of the TM codes.

This new Blue Book would provide a recommended standard way to use a subset of the CCSDS TM codes [1] together with CCSDS modulations [4] in a VCM protocol that is compatible with the existing CCSDS VCM protocol described in [2] and [5].

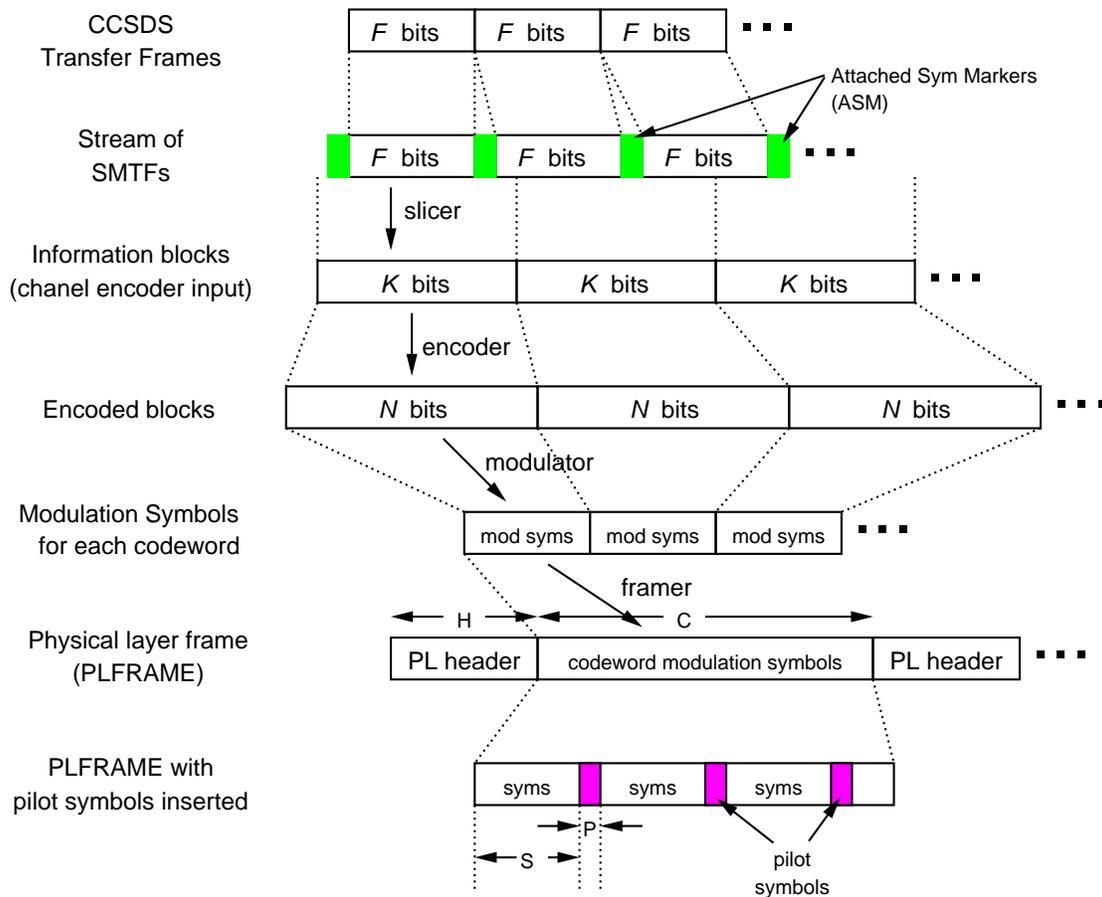
Two independent prototypes will be developed, one by JPL, and one by GSFC.

#### 3) Description of the key technical features

As mentioned above, the two VCM protocols recommended by CCSDS are nearly identical. Figure 1 shows a common framework for the protocol. It operates by taking CCSDS Transfer Frames as input, adding an ASM to form synchronization-marked Transfer frames (SMTFs) (called CADUs in the existing standards), slicing the SMTFs asynchronously into encoder-input-sized blocks, encoding them with a channel code, producing modulation symbols corresponding to the encoded block, prepending a Physical Layer (PL) frame (PLFRAME) header, and optionally inserting pilot symbols within the codeword modulation symbols of the non-header part of the PLFRAME. Transmission consists of a sequence of PLFRAMEs transmitted contiguously without gaps

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The values of  $K$ ,  $N$ ,  $H$ ,  $C$ ,  $S$ ,  $P$  shown in Figure 1 may differ depending on whether SCCC, DVB-S2, or TM codes are used, but otherwise, the overall structure of the VCM protocol remains the same.



**Figure 1. Structure of the PLFRAME of the VCM Protocol.**

The CS and RFM working groups have discussed a draft Red Book VCM protocol specification at several meetings. Initially, the working groups agreed to develop a Recommended Practice (Magenta Book) based on the existing CCSDS VCM protocols and channel codes, i.e., the recommended way of using the existing standard codes with the existing standard VCM protocols. In the course of discussion, the working groups agreed at the Fall 2017 CCSDS meeting that a Blue Book would be a better standards track for this specification.

The specification for the draft Red Book has been updated to reflect the technical comments made at the Fall 2017 CCSDS meeting, and all references to “Recommended Practice” have been changed to “Recommended Standard.”

The primary work remaining is the implementation of two independent prototypes. As discussed at the Fall 2017 CCSDS meeting, JPL will complete one prototype, and GSFC will complete the other. These prototypes will use the channel model used in the past during the standardization of [2] and [3].

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## 4) Expected benefits

The adoption of the VCM protocol as a recommended standard is expected to provide the following benefits:

### 1. **There will be a standard way to use VCM with the TM codes [1]**

The CCSDS TM codes are compatible with VCM, but no standard MODCOD table exists for their use. By providing this table and the associated VCM parameters described above, ground stations supporting the TM codes will be able to configure themselves to use VCM and offer cross-support to other agencies using VCM with TM codes.

### 2. **The VCM protocol will be compatible with the existing SCCC and DVB-S2 VCM protocols.**

Currently VCM is described for the SCCC and DVB-S2 codes, in separate standards. The new Recommended Standard will describe the common framework these two standards use, and without any changes needed to those standards, describe how the TM codes can be used under the same framework.

### 3. **The commonality of the existing SCCC and DVB-S2 VCM protocols will be more readily apparent.**

The new Recommended Standard will describe a VCM protocol framework that applies to SCCC, DVB-S2, and TM codes. This will be the first time a CCSDS standard VCM protocol will be shown to be common to all of these types of codes.

## 5) Requirements of prospective missions

System engineers are constantly looking for ways to increase the data volume return to meet the requirements of planned missions. For this reason, the International Space Station has tested the VCM protocol on its SCan Testbed (formerly called the CoNNeCT radio) in a space-to-ground demonstration. This is providing the necessary TRL advancement for prospective missions beyond 2020 to incorporate VCM into their requirements.

## 6) Relationship to existing standards

CCSDS has three Recommended Standards defining channel codes and one Recommended Standard defining modulations for use on the space-to-Earth link.

The first of the existing coding standards includes convolutional codes, Reed-Solomon codes, turbo codes, and Low-Density Parity-Check (LDPC) codes (reference [1]), to be used with recommended modulations (reference [4]). No VCM protocol is specified in references [1] and [4].

A second Recommended Standard specifies a set of Serially Concatenated Convolutional Codes (SCCCs), together with a set of modulations and a VCM protocol (reference [2]).

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A third Recommended Standard specifies a mechanism to communicate CCSDS Transfer Frames using an existing ETSI standard for Digital Video Broadcasting by Satellites (DVB-S2), which uses BCH codes concatenated with LDPC codes (references [3] and [5]). The DVB-S2 standard (reference [5]), and thus the CCSDS standard (reference [3]), specifies a VCM protocol as well as method for the receiver to monitor quality-of-reception parameters and to communicate this back to the transmitter, as part of an adaptive coded modulation (ACM) protocol.

## 7) Identified deficiencies, flaws, and limitations in existing standards.

The primary limitations of existing standards are:

1. There is no standard method for using VCM with TM codes
2. There is no specification that makes the commonality of the SCCC and DVB-S2 VCM readily apparent.

## References

- [1] *TM Synchronization and Channel Coding*. Issue 3. Recommendation for Space Data System Standards (Blue Book), CCSDS 131.0-B-3. Washington, D.C.: CCSDS, September 2017.
- [2] *Flexible Advanced Coding and Modulation Scheme for High Rate Telemetry Applications*. Issue 1. Recommendation for Space Data System Standards (Blue Book), CCSDS 131.2-B-1. Washington, D.C.: CCSDS, March 2012.
- [3] *CCSDS Space Link Protocols over ETSI DVB-S2 Standard*. Issue 1. Recommendation for Space Data System Standards (Blue Book), CCSDS 131.3-B-1. Washington, D.C.: CCSDS, March 2013.
- [4] *Radio Frequency and Modulation Systems—Part 1: Earth Stations and Spacecraft*. Issue 28. Recommendation for Space Data System Standards (Blue Book), CCSDS 401.0-B-28. Washington, D.C.: CCSDS, February 2018.
- [5] *Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications (DVB-S2)*. ETSI EN 302 307 V1.3.1 (2013-03). Sophia-Antipolis: ETSI, 2013.

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## ANNEX 1 – Proposed Charter Modification

Within goals add the following bullet:

- Blue Book for Variable Coded Modulation (VCM) Protocol

And delete the following bullet:

- Magenta Book for Variable Code and Modulation (VCM)

Remark: the CWE Project for the VCM Blue Book is defined in Annex 2.

## ANNEX 2 – Proposed CWE Projects

**Title:** VCM Protocol

**Document Number:** TBD

**Document Type:** Blue Book

**Description of Document:** This Blue Book will define a CCSDS standard VCM protocol, to be used with a subset of the Telemetry (TM) codes, SCCC codes, and DVB-S2 codes, compatible with existing 131.2-B-1 and 131.3-B-1 Blue Books.

**Applicable Patents:** None (TBC)

**Patents Comments:** None (TBC)

**Book Editor (estimated resources + Agency Volunteering):** Total resources 6 mm shared between ESA, DLR, CNES and NASA. Book editor (NASA)

**Prototype 1 (estimated resources + Agency Volunteering):** 3mm+ NASA/JPL

**Prototype 2 (estimated resources + Agency Volunteering):** 3mm+NASA/GSFC

**Expected Contributing Agencies:** CNES, DLR, ESA, NASA

**Expected Monitoring Agencies:**

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**Schedule: March 2018 – March 2020**

Note: This book has been undergone internal WG review, including first and second drafts, and CESG poll, when it was under consideration as a Magenta Book.

Schedule Milestones	Forecast	Comments
Project Approved (from magenta to Blue)	30 Apr 2018	End of CMC Poll
Final WB Submitted to AD for Further Processing	2 May 2018	Revision agreed at Spring 2018 Meeting
Secretariat Document Processing	15 June 2018	Start of Review after CESG + CMC Polls
First Agency Review	30 August 2018	End of Review
RID Resolution	30 September 2018	Before Fall '18 Meeting
Secretariat Document Processing	1 Feb 2019	Start of 2 <sup>nd</sup> Review (if needed). No Polls.
Final Agency Review	1 Apr 2019	Before Spring 19 Meeting
RID Resolution	31 Jul 2019	After Spring 19 Meeting
First Prototype Development	31 Jul 2019	
Second Prototype Development	31 Jul 2019	
CMC Approval	1 Oct 2019	Includes Final Secretariat Document Processing + CESG Poll + CMC Poll for PUBLICATION