**SLS C&S Working Group**

**Minutes of the Meeting**

# C&S (Mon Oct 15)

## General (AIs etc.)

The agenda and Action Item (AI) list were presented by the Working Group Deputy Chairman. The AI list, updated with the AIs opened at this meeting, is attached to the minutes (Annex 1). AIs originated during the meeting start from AI\_18\_6. The attendance list and agenda are provided respectively in Annexes 2 and 3.

There was particular discussion of AI\_14\_8, about using parallel convolutional encoders when (O)QPSK modulation is used. It was unclear to the working group whether this architecture is already standardized in the RFM Blue Book (401.0-B-28), recommendation 2.4.11 (2). The action item to prepare a concept paper for updating 130.1-G remains with NASA, and the working group will review that concept paper in light of this RFM recommendation.

The working group agreed to postpone the 5-year reconfirmation reviews of 131.3-B-1 (CCSDS Space Link Protocols over ETSI DVB-S2 Standard) and 131.2-B-1 (Flexible Advanced Coding and Modulation Scheme for High Rate Telemetry Applications) until Spring, 2019, in view of the ongoing work to develop DVB-S2x and SCCC-X Orange Books.

## Longer Randomizer for TM Coding and Sync (NASA)

Presentation SLS-CS\_18-10 was given by V. Sank (NASA) on the search for a longer pseudo-randomizer to be used to reduce spectral spurs at high data rates. While the existing PN-8 sequence generates spectral spurs (when applied to non-random data) at 1/255 of the symbol rate, the proposed PN-17 sequence generates a pattern that is longer than the longest codewords. In exchange, the run length properties may degrade. With a properly chosen starting point in the PN-17 sequence, there is no run of length >8 in the first 4524 symbols, or >10 in the first 9524 symbols, or >11 in the first 21429 symbols.

The working group concluded that this run-length study did not fully address AI\_18\_5 which remains open, and requested additional information about the 0/1 bias, transition density, and power spectral density (the initial motivation for this study) in AI\_18\_9. The work has proceeded far enough to justify writing a concept paper to update the TM C&S Blue Book (AI\_18\_7 and AI\_18\_8).

## Performance of VCM over a Nonlinear Channel (NASA)

Presentation SLS-CS\_18-11 was given by W. Fong/NASA on the performance of some of the coded modulations in 431.1-R (Variable Coded Modulation). A nonlinear channel model was described with a phase noise profile, AM/AM and AM/PM nonlinear distortions, and AWGN channel noise. Other simulation elements included an SRRC pulse shaper at the transmitter, and a matched filter, soft-decision demodulator, and LDPC decoder at the receiver. With this system and channel model, the total degradation (demodulation loss plus output back-off) was determined by simulation for VCM mode 9 (rate 2/3 code + QPSK), mode 14 (rate 4/5 code + 8PSK), and mode 23 (rate 7/8 code +32APSK). In the last case, total degradation was reduced by about 2.5 dB by applying centroidal predistortion. Other distortion mitigation techniques are under study.

## VCM Prototype Status (NASA)

Presentation SLS-CS\_18-12 was given by J. Hamkins/NASA, reviewing the status of 431.1-R, “Variable Coded Modulation Protocol”. Based on working group consensus in the spring, a few remaining editorial changes were made and the working group requested that the CESG and CMC conduct polls to begin agency review. Development of interoperable implementations is underway, and will be documented in a Yellow Book (AI\_18\_14).

## Extension of SCCC towards 128- and 256-APSK (ESA)

Presentation SLS-CS\_18-13 was given by A. Modenini/ESA about new options for SCCC (131.2-B) with 128- and 256-APSK modulations. To reduce complexity and to maintain backwards compatibility, a two-stage encoder was proposed, consisting of the backwards-compatible SCCC stage, and a new BCH stage and row-column interleaver. Simulation results were presented for ten new modulation-coding combinations (five each for 128- and 256-APSK), assuming a non-linear channel but perfect symbol synchronization. These achieve a spectral efficiency as high as 7.5 bits/symbol.

ESA will prepare a concept paper to write an Orange Book for SCCC-X (AI\_18\_10), to be reviewed by the working group (AI\_18\_11).

## Status on CCSDS High Data Rate Telemetry (CNES)

Presentation SLS-CS\_18-14 was given by C. Dudal/CNES comparing progress towards high spectral efficiency standards by CNES with DVB-S2X, and by ESA with SCCC-X. Both efforts have proceeded on similar schedules, and both ESA and CNES are proceeding towards development of Orange Books. An action item requesting working group review of the DVB-S2X Orange Book presented at the Spring Meeting was accidentally omitted from the spring minutes; it is now present as AI\_18\_15.

## DVB-S2X benefits for HDRT (CNES)

Presentation SLS-CS\_18-15 was given by C. Dudal/CNES on simulation results about benefits of new modulations with higher spectral efficiencies (64-, 128-, and 256-APSK), new coding rates (21), and new roll-off factors (3) proposed in the DVB-S2X Orange Book. Thirty nine modulation-coding combinations are added (including 8-APSK) and roll-off factors as small as 0.05. To show the potential benefits, a representative mission profile was constructed based on the SENTINEL-1 orbit and CNES CORMORAN ground network. The total data return was calculated using a link budget tool, both with and without a 300 Msps symbol rate constraint. Results showed that in comparison to DVB-S2, DVB-S2X provided a 19.4% gain in data volume with the 300 Msps constraint, and 31.6% gain without it, benefiting from the lower roll-off factor. However, it was unclear how these percentages were computed, and the Working Group requested clarification (AI\_18\_12), followed by working group review (AI\_18\_13).

## Modifications to 131.0-B to add AOS and USLP Uplink (NASA)

Presentation SLS-CS\_18-16 was given by K. Andrews/NASA about potential methods to add a “forward frame service” that combines the codes in 131.0-B (TM C&S Blue Book) with the AOS or USLP link protocols for use on ground-to-space links. The initial action item (AI\_17\_04) called for the down-selection of codes from 131.0-B, and this could be done by adding a chapter to that book. Alternatively, a new “Profiles” book could be written that would have larger scope, also addressing the SCCC and DVB-S2 Blue Books, and perhaps also space-to-space and space-to-ground links. Drafts of both approaches were presented. Based on the ensuing discussion in this session, the consensus favoured writing a new Blue Book that would cover both the codes in 131.0-B (TM C&S) and 131.2-B (SCCC). However, this was modified in the joint session; see the discussion in Section 2.1 below.

## USLP Interoperability Test Results with Prox-1 (NASA)

Presentation SLS-CS\_18-17 was given by G. Kazz/NASA about the addition of the USLP data link protocol to the Prox-1 Coding and Synchronization Blue Book, 211.2-B. Edits to the book were presented, most notably defining a Transfer Frame to refer either to a Version-3 (Prox-1) or Version-4 (USLP) transfer frame, and resolving differences in the frame length field. It was also noted that because the Prox-1 C&S layer adds a Cyclic Redundancy Check (CRC-32) to the transfer frames, the USLP protocol should not add a Frame Error Control Field (FECF) in this case.

Interoperability tests were performed by Kevan Moore of NASA/MSFC, and Stefan Veit of DLR. Most challenging was proper resynchronization after a frame was corrupted and dropped due to a faulty CRC. The interoperability tests were reported to be successful.

The Working Group resolved to submit the updated 211.2-B document to the Area Director for CESG/CMC polls to begin agency review.

# Joint C&S/RFM (Tue OCT 16)

## Modifications to 131.0-B to add AOS and USLP Uplink (NASA)

While not on the agenda, those in attendance agreed to revisit the “forward frame service” topic previously discussed in the C&S meeting. After a brief review of presentation SLS-CS\_18-16, discussion resumed about the preferred path forward. The working group consensus was that modifications should made in parallel to 131.0-B, 131.2-B, and 131.3-B, and this is not compatible with simply adding a chapter to 131.0-B. Instead, the specifications about both link direction (e.g. space-to-ground) and supported space link protocols (e.g. TM, AOS, or USLP) should be deleted from all three C&S books, and a new “Profiles” book would be written to specify the recommended combinations of codes, link directions, and protocols. While nobody present would speak with authority about the colour of the Profiles book to be written, many knew that Peter Shames believed it should be a normative Blue Book. All of these activities will be captured in a single concept paper (AI\_18\_16), to initiate new projects for each of the books to be edited.

## Longer Randomizer for TM Coding and Sync (NASA)

Presentation SLS-CS\_18-10 was summarized by V. Sank (NASA) for those who had missed the longer discussion the previous day. Please refer to the relative item under the C&S section for further information.

## Performance of VCM over a Nonlinear Channel (NASA)

Presentation SLS-CS\_18-11 was summarized by W. Fong/NASA for those who had missed the longer discussion the previous day. Please refer to the relative item under the C&S section for further information.

## VCM Prototype Status (NASA)

Presentation SLS-CS\_18-12 was summarized by J. Hamkins/NASA for those who had missed the longer discussion the previous day. Please refer to the relative item under the C&S section for further information.

## Extension of SCCC towards 128- and 256-APSK (ESA)

Presentation SLS-CS\_18-13 was summarized by A. Modenini/ESA for those who had missed the longer discussion the previous day. Please refer to the relative item under the C&S section for further information.

## DVB-S2X benefits for HDRT (CNES)

Presentation SLS-CS\_18-15 was summarized by C. Dudal/CNES for those who had missed the longer discussion the previous day. Please refer to the relative item under the C&S section for further information.

# Annex 1: Action Item List

Open action items are listed in the table below. AIs originated in Berlin start from AI\_18\_6.

|  |  |  |  |
| --- | --- | --- | --- |
| **AI#** | **Action** | **Actionee** | **Due Date** |
| **AI\_14\_8** | Prepare concept paper to initiate a new project for updating 130.1-G with coded OQPSK architecture and other material | V. Sank/NASA and K. Andrews/NASA | Nov. 2018 |
| **AI\_16\_12** | Include results based on the MRB decoder in the TC GB. Include also complexity estimate | M. Bertinelli/ESA | Spring 2019 |
| **AI\_16\_13** | Prepare a paper on acquisition/tracking issues and results with short LDPC coding for TC | M. Bertinelli/ESA | Spring 2019 |
| **AI\_17\_03** | Prepare a concept paper to initiate the study of suitable solution to fading on the telemetry channel, e.g. channel interleaving.Modified Fall 2018: Add note to TM GB about vulnerability of turbo codes to burst errors. | K. Andrews/NASA | Spring 2019 |
| **AI\_17\_04** | Prepare a concept paper for the study/selection of the coding options, out of 131.0-B, to be made applicable to AOS uplink | K. Andrews/NASA | Closed; superseded by AI\_18\_16 |
| **AI\_18\_1** | Include acronyms for the equations in the BP-layered related sections of 230.1-G | Y.Fan/CAS, K. Andrews/NASA, M. Bertinelli/ESA | Spring 2019 |
| **AI\_18\_2** | Include measured phase noise in the draft 130.11-G Green Book | M. Bertinelli/ESA | Closed |
| **AI\_18\_3** | Provide comments to the draft 130.11-G Green Book | WG members | Closed |
| **AI\_18\_4** | Draft a "standardized" channel model to be used for simulations | W. Fong | Spring 2019 |
| **AI\_18\_5** | Extend the randomizer study considering the impact on the (symbol) tracking loop and on meeting the power flux density limits | H. Garon | Spring 2019 |
| **AI\_18\_6** | WG review of concept paper to add parallel convolutional encoders to 130.1-G (TM C&S), following AI\_14\_8 | WG members | Dec. 2018 |
| **AI\_18\_7** | Prepare concept paper to initiate a new project to add longer randomizer to 131.0-B (TM C&S) | V. Sank/NASA and K. Andrews/NASA | Nov. 2018 |
| **AI\_18\_8** | WG review of concept paper to add longer randomizer to 131.0-B (TM C&S), following AI\_18\_7 | WG members | Dec. 2018 |
| **AI\_18\_9** | Report on 0/1 bias, transition density, and power spectral density performance of longer randomizer with respect to theory | V. Sank/NASA | Spring 2019 |
| **AI\_18\_10** | Prepare concept paper to initiate a new project to write an Orange Book for SCCC-X | A. Modenini/ESA | Nov. 2018 |
| **AI\_18\_11** | WG review of concept paper for SCCC-X Orange Book, following AI\_18\_10 | WG members | Dec. 2018 |
| **AI\_18\_12** | Clarify results presented in SLS-CS\_18-15 (DVB-S2X benefits): gain percentages | C. Dudal/CNES | Nov. 2018 |
| **AI\_18\_13** | WG review of clarifications provided for SLS-CS\_18-15 (DVB-S2X benefits), following AI\_18\_12 | WG members | Dec. 2018 |
| **AI\_18\_14** | Prepare Yellow Book documenting VCM implementations | J. Hamkins/NASA | Spring 2019 |
| **AI\_18\_15** | WG review of DVB-S2X Orange Book from Spring 2018 | WG members | Jan. 31, 2019 |
| **AI\_18\_16** | Prepare a concept paper to 1) rename, remove link directions and protocol names from TM C&S BB, 2) remove link directions and protocol names from SCCC BB, 3) remove link directions and protocol names from DVB-S2 BB, and 4) prepare new Profiles BB to recommend combinations of codes, protocols, and link directions | K. Andrews/NASA, E. Vassallo/ESA, and C. Dudal/CNES | Dec. 2018 |

# Annex 2: List of participants

Attached list reports participants to at least one of the C&S meeting sessions.

|  |  |  |
| --- | --- | --- |
| **Name** | **Affiliation** | **e-mail** |
| Ricard Abello | ESA | ricard.abello@esa.int |
| Brent Andres | NASA | brent.r.andres@nasa.gov |
| K. Andrews (deputy chair) | NASA | andrews@shannon.jpl.nasa.gov |
| Ivan Antonov | ROSCOSMOS | aid@mcc.rsa.ru |
| G. P. Calzolari | ESA | gian.paolo.calzolari@esa.int |
| Joseph Downey | NASA | joseph.a.downey@nasa.gov |
| C. Dudal | CNES | Clement.dudal@cnes.fr |
| Xavier Enrich | EUMETSAT | xavier.enrich@eumetsat.int |
| Michael Epperly | SWRI | mepperly@swri.edu |
| Y. Fan | CAS | fanyanan@nssc.ac.cn |
| Ivan Filatov | ROSCOSMOS | iwfilatov@gmail.com |
| W. Fong | NASA | wai.h.fong@nasa.gov |
| Thomas Gannett | NASA | Thomas.gannett@tgannett.net |
| A. Geda | DLR | amanuel.geda@dlr.de |
| J. Hamkins | NASA | jon.hamkins@jpl.nasa.gov |
| I. Kalininskaya | FSA | i.kalininskaya@mail.ru |
| G. Kazz | NASA | greg.j.kazz@jpl.nasa.gov |
| Louise Medova | ROSCOSMOS | medova.lr@mipt.ru |
| Jean-Pierre Millerioux | CNES | jean-pierre.millerioux@cnes.fr |
| Andrea Modenini | ESA | Andrea.modenini@esa.int |
| G. Moury | CNES | Gilles.moury@cnes.fr |
| Dmitrii Nagozhykh | ROSCOSMOS |  |
| L. Pitts | NASA | Robert.l.pitts@nasa.gov |
| S. Rodriguez | NASA | Shannon.rodriguez-1@nasa.gov |
| V. Sank | NASA | victor.j.sank@nasa.gov |
| G. Sessler | ESA | Gunther.sessler@esa.int |
| A. Skirkov | FSA | Sav89@mail.ru |
| E. Vassallo | ESA | enrico.vassallo@esa.int |
| S. Veit | DLR | stefan.veit@dlr.de |
| Valery Vorontsov | ROSCOSMOS | a762642@yandex.ru |

# Annex 3: Agenda

**Oct 15 Mon** 09:45-12:30 (**C&S**, Room 0104 a)

|  |  |  |  |
| --- | --- | --- | --- |
| N° | **Agenda Topic** **C&S** | Time allocation in minutes | REMARKS |
| 1 | General issues, Review of Actions, etc.  | 30 |  |
|  |  |  |  |
| 2 | Response to Action Item on Acquisition of new suggested Longer Randomizer (NASA/GSFC) | 30 | SLS-CS\_18-10 |
|  |  |  |  |
| 3 | Performance of Variable Coded Modulations over a Nonlinear Channel for VCM Protocol Red Book (NASA/GSFC) | 30 | SLS-CS\_18-11 |
|  |  |  |  |
| 4 | VCM prototype status (NASA/JPL) | 30 | SLS-CS\_18-12 |
|  |  |  |  |
|  | Coffee Breaks 20’ | 20 |  |
| **TOTAL hours** | **2h 20’** |  |

**Oct 15 Mon** 13:30-17:30 (**C&S**, Room 0104 a)

|  |  |  |  |
| --- | --- | --- | --- |
| N° | **Agenda Topic** **C&S** | Time allocation in minutes | REMARKS |
| 1 | Extension of SCCC towards 128- and 256-APSK (SCCC-X) – Status Update (ESA) | 30 | SLS-CS\_18-13 |
|  |  |  |  |
| 2 | Status on CCSDS High Data Rate Telemetry Projects (CNES) | 30 | SLS-CS\_18-14 |
|  |  |  |  |
| 3 | DVB-S2X benefits for HDRT (CNES) | 30 | SLS-CS\_18-15 |
|  |  |  |  |
| 4 | Modifications to the TM Synch and Channel Coding book for AOS and USLP Uplink (NASA/JPL) | 30 | SLS-CS\_18-16 |
|  |  |  |  |
| 5 | USLP Interoperability Test Results with Prox-1 C&S Sublayer (NASA/JPL) | 15 | SLS-CS\_18-17 |
|  |  |  |  |
|  | Coffee Breaks  | 20 |  |
| **TOTAL hours** | **2h 35’** |  |

**Continued on next page**

**Oct 16 Tue** 08:45-12:30 (**C&S**, Room 0104 a)

|  |  |  |  |
| --- | --- | --- | --- |
| N° | **Agenda Topic** **C&S** | Time allocation in minutes | REMARKS |
| 1 | Open | 120 |  |
|  |  |  |  |
|  | Coffee Breaks  | 20 |  |
| **TOTAL hours** | **2h 20’** |  |

**Oct 16 Tue** 13:30-17:30 (**Joint C&S/RFM**, Room 0101)

|  |  |  |  |
| --- | --- | --- | --- |
| N° | **Agenda Topic** **Joint C&S/RFM** | Time allocation in minutes | REMARKS |
| 1 | Response to Action Item on Acquisition of new suggested Longer Randomizer (NASA/GSFC) | 30 | SLS-CS\_18-10 |
|  |  |  |  |
| 2 | Performance of Variable Coded Modulations over a Nonlinear Channel for VCM Protocol Red Book (NASA/GSFC) | 30 | SLS-CS\_18-11 |
|  |  |  |  |
| 3 | VCM prototype status (NASA/JPL) | 30 | SLS-CS\_18-12 |
|  |  |  |  |
| 4 | Extension of SCCC towards 128- and 256-APSK (SCCC-X) – Status Update (ESA) | 30 | SLS-CS\_18-13 |
|  |  |  |  |
| 5 | Status on CCSDS High Data Rate Telemetry Projects (CNES) | 30 | SLS-CS\_18-14 |
|  |  |  |  |
| 6 | DVB-S2X benefits for HDRT (CNES) | 30 | SLS-CS\_18-15 |
|  |  |  |  |
|  | Coffee Breaks | 20 |  |
| **TOTAL hours** | **3h 20’** |  |