**SLS C&S Working Group**

**Minutes of the Meeting**

Meetings took place in hybrid format, in person in Toulouse and by teleconference. Meetings were held on 19th and 20th October 2022.

# Joint SLP, C&S, and OPT

The joint meeting was organized with the objective of possibly implementing variable length frames (VLFs) in CCSDS standards.

## VLFs – Review of Mission Needs (SLS-CS\_22-10)

N. Maturo/ESA gave a presentation about the possible application of VLFs for Earth Observation (EO) and Science (SCI) missions, by using as reference actual ESA space missions as CHIME and GAIA.

Both missions have variable length packets, generated by the instruments, that are encapsulated into CCSDS space packets (SP). The advantage of having VLFs would be to bypass the SP layer. However, it was shown that (for this kind of missions) there was a limited saving in overhead, thus making VLFs not a need for EO and SCI missions, but rather a nice-to-have.

The presentation concluded by recalling that in CCSDS Spring 2022 it was discussed that VLFs could be also useful for transmitting Ethernet packets, but, for classical EO/SCI missions, if these are needed, the standard IPoCCSDS can be adopted.

ESA clarified that the presentation is applicable only to EO/SCI missions, while other scenarios (e.g., future Lunar missions) were not assessed.

B. Edwards/OCWG commented that the discussion/question on if there is advantage to have ethernet packets directly inside the transfer frame came from private companies in the Optical Comm WG meetings, and the WG’s effort to try to get the optical comm standards to be used by outside.

## Variable length USLP Transfer Frames – LTPv2 Use case (SLS-CS\_22-11)

F. Flentge/ESA provided a presentation about the ESA high-rate LTP study, for defining an open ARQ scheme for less reliable links (K-Band and Optical) for replacing proprietary schemes in use on optical links.

As result of the study, it is foreseen to run LTPv2 without packet layer because of the followings:

* APID is not required if LTP is applied to all data;
* LTPv2 frame layer simplifies implementation and saves some small overhead;
* LTPv2 is attractive for non-Agency use cases.

Being the LTP segments variable length, it would require VLFs.

In turn, at coding & synchronization layer, there could two options considered for implementing VLFs:

* Variable-length USLP, with classical ASM, but requiring the need to read the frame length (causing thus a layer violation);
* Generic frame procedure (GFP) that avoids the layer violation and provides compatibility with other frame formats (e.g., Prox-1, Ethernet, etc.).

Currently, ESA preference in this framework is for GFP. The ESA study foresees also the implementation of a prototype that implements the network layers.

## Failure analysis for GFP (SLS-CS\_22-15)

Input provided by W. Fong/NASA in response to AI\_22\_02, that assess the probability of a false alarm and misdetection for GFP.

During the hunt state, it was shown that the probability of false alarm (likelihood that a random pattern of 4 bytes is mistaken for a core header) increases with the frame length, tending to 1 for the largest frame length 65536. This can be decreased by checking at least 3 to 4 core headers for the largest frame, i.e., waiting 3 to 4 frames before going on lock state, or by using an expanded core header.

Instead the classical ASM has a probability of false alarm that is ~1e4 times less likely than that of the GFP core header.

Differently, the probability of misdetection for GFP is limited by the BER/FER.

J. Hamkins/NASA provided comments about the presentation as follows:

* There is no need to use the CRC in the CHEC field for SEC or multi-bit error detection;
* The expression of P\_FA(L) works just for small L;
* Two core headers should have similar performance to the classical ASM;
* Latency should not be an issue with GFP: in optical latency is driven by the channel interleaver. In RF transmission, 3-4 frames latency is present just during acquisition.

A. Modenini/ESA commented that ESA is performing internally some simulations of GFP, and obtained similar results for P\_FA(L) to those of W. Fong/NASA.

## VLFs – way forward discussion

Presentations on VLFs were follow up by an open discussion about the way forward to be taken.

The WGs, from one side, found that VLFs are not required by near future space missions while, on the other side, VLFs (and in particular GFP) are seen as an important enabler for optimizing very high data rate links (optical, and future RF), i.e > 10 Gbps.

M. Cosby/UKSA commented that optical communication industry is pushing for VLFs, with different motivations from agencies.

It was finally reached consensus that C&S WG shall implement a transfer frame slicer for the coding schemes listed in the blue books. The slicer should be standardised possibly as a shim book, so that it can be adopted by different C&S blue books: 131.0-B (TM), 131.2-B (SCCC), 131.3-B (DVB-S2) and 142.0-B (optical).

With this approach, the slicer allows either (see Figure 1) to use fixed-length TM/AOS/USLP frames (as currently done) as generic SMTF stream, or to use standards coming from other entities (e.g., ITU GFP).

Slicer (optional)

Coding layer

TM/AOS/USLP

RF layer

slicer

Coding layer

Generic VLFs standard (non CCSDS)

RF layer

**Figure 1: sketch of the possible stacks possible by implementing a shim book for slicing transfer frames.**

As a result, VLFs (for the time being) will not be introduced as part of CCSDS standards, but rather CCSDS standards will provide an interface for allowing commercial operators to use their own VLFs standards (including GFP).

C&S WG will prepare a concept paper about slicing (**AI\_22\_06**).

# C&S

## Extending slicing to all other block codes in CCSDS 131.0-B (SLS-CS\_22-12)

Presentation of K. Andrews/NASA. It was proposed to delete Chapter 8 (LDPC of SMTFs) and include slicing as a dedicated sublayer.

The WG had consensus on the proposed technical implementation, by specifying that there should be only one codeword or codeblock per CSM (i.e., equivalent of setting the parameter m in Slide 2 equal to 1). The WG had also consensus to have meanwhile a technical corrigendum (**Resolution#1**).

The presentation included also a draft of the pink sheets for implementing the sublayer in 131.0-B. However, following the joint SLP/OPT/C&S meeting, it is now required to re-organize these changes as part of a dedicated shim book (**AI\_22\_07**).

## Simulation and Breadboard results of the Turbo Channel Interleaver (SLS-CS\_22-14)

R. Prada, DEIMOS, on behalf of ESA gave a presentation about the breadboard results of the turbo channel interleaver. Test results show a good matching with the numerical simulations, thus indicating that the interleaver implementation is working.

As annex to the presentation, a draft book was provided, containing useful material for both the future 131.0-B and 131.0-G updates. ESA has still a pending action item for providing draft pink sheets (**AI\_21\_02**), for which it can now possibly use this material.

I. Aguilar/SLS AD pointed out that a second prototype, as reported in the CWE project, shall be implemented. The second prototype can be also in software. K. Andrews/NASA took action to implement such prototype by Fall 2023 (**AI\_22\_08**).

## Concept paper for S-Band proximity-1

A. Modenini/ESA presented the draft concept paper for having a project on the extension of Proximity-1 to S-Band and, possibly, K-Band.

Some minor edits were included in the paper during the meeting. The paper was presented the day after in the joint SLP/C&S/RFM meeting.

## C&S working group status

A. Modenini/C&S Chair provided a brief presentation on the C&S working group status, covering the following topics:

* Project Status Review, with a quick overview of all C&S CWE projects and activities, with special focus on the following items:
  + *TM Blue Book randomizer*,
  + *TM Blue Book with slicing*,
  + S-Band proximity-1,
  + *Turbo Channel Interleaver*,
  + *Variable length frames*,
  + *Open Inter-Satellite Network (OpenISN).*
* Review of AIs

Among the activities, there is a pending update of the AOS maximum frame length, following the update of the first bit header pointer done by SLP (see thread *[Sls-slp] Extending the 1st Header Pointer in AOS to 16 bits to cover max Transfer Frame length,* under CWESLP mail archives).

The WG agreed to have a technical corrigendum (**Resolution#1**), and A. Modenini/C&S Chair to inject it possibly as part of the TM Randomizer agency review (**AI\_22\_09**).

For status of AIs, see Annex 2.

# Joint RFM, C&S, and SLP

## Proximity-1 Extension: analysis of the impact on the blue book

N. Maturo/ESA gave a presentation about the changes to be implemented in the three Proximity-1 blue books (physical layer, coding & synchronization, and data link) for including the followings:

* GMSK and OQPSK,
* LDPC 2/3,
* S-Band channel frequencies;
* USLP transfer frames.

During the technical discussion, it was raised the doubt if the inclusions provided above (in particular OQPSK) match the lunar profiles foreseen by LunaNet, ICSIS, IOAG, and other lunar standardization groups.

S. Rodriguez/NASA took action for reviewing the modulation and coding profiles of future lunar missions (**AI\_22\_10**), for confirming that all items above are sufficient for covering future mission needs.

N. Maturo/ESA and A. Modenini/ESA took action (**AI\_22\_11**) for providing draft pink sheet of Proximity-1 211.1-B (physical layer) and 211.2-B (coding and synch layer), implementing the changes above (pending confirmation of AI\_22\_10).

G. Kazz/NASA took action (**AI\_22\_12**) for providing draft pink sheet of Proximity-1 211.0-B (data link layer), implementing the changes above (pending confirmation of AI\_22\_10)

## Concept paper for S-Band proximity-1

A. Modenini/ESA presented the draft concept paper for having a project on the extension of Proximity-1 to S-Band and, possibly, K-Band.

During the presentation of the concept paper, J. Issler/CNES commented about the applicability of frequency management recommendations (e.g., SFCG), in particular the maximum occupied bandwidth and frequency assignments.

A. Modenini/ESA proposed to use the following approach:

* A. Modenini/ESA, J. Issler/CNES, D. Lee/NASA to monitor working activities in SFCG;
* to ensure that the modulation and coding formats that will be provided in the blue books allow the designer to meet possible future recommendations on the occupied bandwidth;
* to decide later on if proximity-1 physical layer blue book should define the exact frequency assignments (as done for UHF), or rather define just the channels for which frequency assignment is decided on a mission basis.

Considering that the three points above can be considered part of normal work, and do not impact the concept paper, the three WGs had consensus to send the concept paper to SLS for formal approval (**resolution #2**).

## ISN: updates from CESG

Following input SLS-CS\_22-07, presented at Spring 2022, A. Modenini/C&S chair provided an update of the activities. Namely, input SLS-CS\_22-07 was presented by SLS AD to CESG for discussing the possibility of having a joint project for implementing a Magenta Book that defines guidelines for implementing a Lunar Inter-satellite Network (Lunar ISN).

As a result, CESG agreed to task the SLS-C&S/RFM/SLP, together with SIS-DTN and SEA-SA for preparing a concept paper, to be led by A. Modenini/C&S chair, together with F. Flentge/ESA and P. Shames/SEA AD.

A. Modenini/C&S took action (**AI\_22\_13**) to provide to the three WGs the latest technical information coming from CESG discussion and the draft of the concept paper.

# resolutions

This section provides a list of C&S WG resolutions during CCSDS Spring 2022 meeting.

* **Resolution#1:** To have a technical corrigendum of 131.0-B for
  + Havingthe slicing done by LDPC of SMTFs with one codeword per CSM (m=1), and
  + having AOS maximum frame length increased to 65536 octets.
* **Resolution#2 (joint SLP/C&S/RFM)**: To send Proximity-1 extension concept paper to SLS for project approval.

Additionally, the following resolutions are planned in the next 6 months:

* Approval of CWE project for Lunar ISN Magenta Book (cross area);
* Approval of CWE project for Transfer Frame Slicing.

**Annex 1: Agenda**

Inputs available on CWE (private folder) at <https://tinyurl.com/347edjft>

**Wednesday, October 19, 2022 – 08:45-12:30 (CET)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| N° | **Author** | **Agenda Topic**  **SLP/C&S/OPT joint meeting** | | Time allocation in minutes | REMARKS |
| 1 | ESA | VLFs – Review of Mission Needs | | 30 | SLS-CS\_22-10 |
| 2 | ESA | Variable-length USLP Tranfer Frames – LTPv2 Use case | | 30 | SLS-CS\_22-11 |
| 3 | NASA | Failure analysis for GFP | | 30 | SLS-CS\_22-15 |
| 4 | WGs | VLFs - way forward discussion | | 60 | N/A |
|  | | | **TOTAL hours** | **2.5** |  |

**Wednesday, October 19, 2022 – 13.30-17.30 (CET)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| N° | **Author** | **Agenda Topic**  **C&S meeting** | | Time allocation in minutes | REMARKS |
| 1 | ESA/NASA | Extending slicing to all other block codes in CCSDS 131.0-B | | 30 | SLS-CS\_22-12 |
| 2 | ESA (Deimos) | Simulation and Breadboard results of the Turbo channel interleaver | | 30 | SLS-CS\_22-14 |
| 3 | ESA | Concept paper for S-Band proximity-1 (presented in preparation of joint meeting with RFM/SLP) | | 30 | SLS-CS\_22-16 |
| 4 | Chair | C&S working group status:   * Project status review; * AoB; * Review of AIs. | | 60 | N/A |
|  | | | **TOTAL hours** | **2.5** |  |

**Thursday, October 20, 2022 – 08:45-12.30 (CET)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| N° | **Author** | **Agenda Topic**  **RFM/SLP/C&S meeting** | | Time allocation in minutes | REMARKS |
| 1 | ESA | Proximity-1 Extension: Analysis of the impact on the Blue Books (joint SLP/C&S/RFM meeting) | | 60 | SLS-CS\_22-13 |
| 2 | Chairs | Concept paper for S-Band proximity-1 | | 30 | SLS-CS\_22-16 |
| 3 | Chairs | ISN: updates from CESG | | 30 | N/A |
|  | | | **TOTAL hours** | **2.0** |  |

# Annex 2: Action Item List

Open action items are listed in the table below. AIs closed during this meeting are cancelled out in the table below.

The New AIs are those starting from AI\_22\_06.

Latest version of AI list can be found on CWE: <https://tinyurl.com/jyrjpz6a>

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **AI#** | **Action** | **Actionee** | **Due date** | **Status** |
| **AI\_20\_07** | Consider extending the simulator channel model work in order to establish procedures for the end-to-end assessment of coding proposals | W. Fong/NASA | ~~Spring 2021~~  ~~Fall 2021~~  ~~Spring 2022~~  ~~Fall 2022~~  Spring 2023 | Open |
| **AI\_21\_02** | Provide a draft recommended standard (as edit of CCSDS 131.0) for including the Turbo interleaver  NOTE: to possibly use input provided by Deimos during Fall 2022 (SLS-CS\_22-14), and to do in liaison with 131.0-B updates for the slicer (AI\_22\_07). | A. Modenini/ESA  N. Maturo/ESA  J. Quintanilla/ESA | Spring 2023 | Open |
| **~~AI\_22\_01~~** | ~~CCSDS member agencies to provide a list of VLFs uses and need cases, especially those that cannot be covered by the existing CCSDS standards, as input to the concept paper~~ | ~~SLS/OPT/C&S WG members~~ | ~~July 2022~~ | ~~Closed~~ |
| **~~AI\_22\_02~~** | ~~CCSDS member agencies to assess(\*) the use of VLFs (for both ASM extension and GFP approaches) and provide their view by next CCSDS Fall meeting.~~  ~~(\*) The assessment should possibly include advantages/disadvantages, impact on heritage (both space and ground), and performance analysis (e.g., miss detection, false alarm, etc.), relying also on public available technical reports.~~ | ~~SLS/OPT/C&S WG members~~ | ~~Fall 2022~~ | ~~Closed~~ |
| **~~AI\_22\_03~~** | ~~to provide a draft of the CCSDS 131.0-B that extends slicing to all other block codes when using fixed-length frames.~~ | ~~V. Sank/NASA~~  ~~A. Modenini/ESA~~  ~~N. Maturo/ESA~~  ~~K. Andrews/NASA~~ | ~~Spring 2023~~ | ~~Closed~~ |
| **~~AI\_22\_04~~** | ~~To prepare a presentation for SLS AD about defining a CCSDS book (color TBC) for having an ISL architecture based on CCSDS standards~~ | ~~A. Modenini/ESA~~  ~~G. Kazz/NASA~~  ~~D. Lee/NASA~~ | ~~27 June 2022~~ | ~~Closed~~ |
| **~~AI\_22\_05~~** | ~~To prepare a concept paper for having a CWE project about the extension of Proximity-1 to S-Band~~ | ~~D. Lee/NASA~~  ~~A. Modenini/ESA~~ | ~~27 June 2022~~ | ~~Closed~~ |
| **AI\_22\_06** | To prepare concept paper about slicing of transfer frames | A. Modenini/ESA | November 2022 | Open |
| **AI\_22\_07** | To prepare a draft blue book that defines the transfer frame slicing as a sub-layer. The draft blue book shall be possibly a shim book between TM/AOS/USLP BBs and C&S BBs. | K. Andrews/NASA  N. Maturo/ESA V. Sank/NASA | Spring 2023 | Open |
| **AI\_22\_08** | To implement a SW prototype for the Turbo Channel Interleaver | K. Andrews/NASA | Fall 2023 | Open |
| **AI\_22\_09** | To prepare C&S resolution for AOS max length technical corrigendum, and possibly inject changes as part of TM BB randomizer Agency Review | A. Modenini/ESA | Fall 2023 | Open |
| **AI\_22\_10** | To review modulation and coding profiles of future lunar missions (stemming from IOAG, ICSIS, LunaNet, etc.) for confirming that GMSK, OQPSK, LDPC 2/3 are sufficient for covering future mission needs. | S. Rodriguez/NASA | Spring 2023 | Open |
| **AI\_22\_11** | To provide draft pink sheets for Proximty-1 211.1-B (ph. Layer) and 211.2-B (c&s layer), implementing the changes agreed by the WG and pending confirmation of AI\_22\_10  NOTE: related action items for 211.1-B and 211.o-B (phy. Layer and data link layer) are tracked in SLP ad RFM WGs. | N. Maturo/ESA A. Modenini/ESA | Spring 2023 | Open |
| **AI\_22\_12** | to provide to SLP/C&S/RFM WG latest technical information coming from CESG discussion about Lunar ISN, and a draft of the concept paper for implementing a magenta book that defines the protocol stack | A. Modenini/C&S chair | November 2022 | Open |

**Annex 3: list of participants**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Name** | **Affiliation** | **Joint  SLP/OPT/C&S** | **C&S** | **Joint SLP/RFM/C&S** |
| R. Abello Puyuelo | ESA | x | x | x |
| I. Aguilar Sanchez | ESA | x | x | x |
| G. Kazz | NASA | x |  | x |
| V. Sank | NASA | x | x | x |
| W. Lee | NASA | x | x | x |
| D. Ni | NASA | x | x | x |
| A. Modenini | ESA | x | x | x |
| J. Quintanilla | ESA | x | x | x |
| S. Veit | DLR | x | x | x |
| W. Fong | NASA | x | x | x |
| M. Cosby | UKSA | x | x | x |
| K. Andrews | NASA | x | x | x |
| B. Ripani | ESA | x | x | x |
| M. Bertolucci | IngeniArs (associate) | x | x | x |
| R. Cassettari | IngeniArs (associate) | x | x | x |
| P. Shames | NASA | x |  |  |
| G. Sessler | ESA | x | x | x |
| J. Hamkins | NASA | x |  |  |
| D. Faramaz | NASA |  |  | x |
| N. Maturo | ESA | x | x | x |
| M. Vialard | CNES | x | x | x |
| J. Issler | CNES | x | x | x |
| S. Rodriguez | NASA | x | x | x |
| M. Rovatti | ESA | x |  | x |
| D. Lee | NASA | x | X | x |
| A. Geda | DLR | x | x | x |
| X. Enrich | EUMETSAT | x | x | x |
| R. Prata | DEIMOS (ESA) |  | x |  |
| G. Moury | CNES | x |  |  |
| B. Quaranta | ESA | x |  |  |
| F. Flentge | ESA | x |  |  |
| C. Heese | ESA | x |  |  |
| H. Dreihahn | ESA | X |  |  |
| K. Oestreich | TESAT | x |  |  |
| P.D. Arapoglou | ESA | x |  |  |
| S. Petri | ESA |  | x | x |