



Jet Propulsion Laboratory
California Institute of Technology

High Photon Efficiency (HPE) Recommendation Status

Jon Hamkins

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Physical Layer - Recent Activity

- Barkley, Shames, and de Cola stated conditions for approving the Draft Red Book.
- These conditions were discussed in the Sep. 12 teleconference.
- Consensus Working Group response was developed, and sent to Gian Paolo.
- Gian Paolo distributed the Working Group response to Barkley, Shames, and de Cola.
- Barkley and de Cola declared that they are satisfied with the response and now approve.
- Shames stated that three concerns remain for him (Oct. 11).
- Further communication with Shames has resolved these issues. See following pages.
- Agreed-to changes have been implemented in a revised Draft Red Book
- Other changes in revised Draft Red Book:
 - Specification of the downlink center frequency, as it relates to the ITU-T grid, has been rewritten and referenced.
 - Minor rewording

Physical Layer - Approval Conditions: Shames (1/2)

- Peter Shames (Approve with Conditions):

1. Definitions appear to be incomplete

Response: Condition #1 rejected. The terms “pulse,” “pulse repetition rate,” “laser line width,” and “spill over emissions” are familiar to persons trained in the field of optical communications. The book needn’t define these general terms unless some aspect of the specification is ambiguous without further definition. The requirements relating to them are already crisply stated in the text. E.g., for spill over emissions, the requirement is “The laser shall transmit 95 percent of its energy within +/-10 GHz of its center frequency.” By way of comparison, in 131.0-B-3, there is no definition of the general terms “code rate,” “sync marker,” “randomization,” etc.

Updated response: Accepted. A section with defined terms has been added.

1. Several abbreviations used without being defined.

Response: Condition #2 accepted. The document will be revised so that all abbreviations and acronyms are expanded in their first use.

2. SANA and Patent sections are missing, they could at least be sketched in at this point. There are a few SANA Registries that will need to be updated to add optical comm coverage.

Response: Condition #3 accepted. Words will be added to clarify that there are no known patents relating to the specification. Jon Hamkins will work with Peter Shames during Agency Review to identify the relevant SANA registries.

3. Rationale is weak, it essentially says “CCSDS says there should be one, but we did not provide even a hint.”

Response: Condition #4 rejected. The rationale is exactly the same as the 131.0-B-2 book, and WG believes it is acceptable, but if the concern persists, wording can be altered in agency review.

Updated response: Accepted. A more detailed rationale has been written.

Physical Layer - Approval Conditions: Shames (2/2)

- Peter Shames (Approve with Conditions):
 - In addition, Peter Shames provided a marked up PDF copy of the book

Response: Some of the suggested improvements are accepted as per following list:

- “add space to space?”
Response: Rejected. This spec does not apply to space-to-space.
Updated Response: Partially accepted. Book states that other applications are not precluded.
- Change “space links” to “optical space links”:
Response: Accepted.
- “Isn’t C-band 4-7 GHz?”:
Response: Accepted. Words will be added to clarify the meaning of optical C-band (opposed to RF C-band).
- [1] should be [2]?
Response: Accepted.
- “Expand RHCP”
Response: Accepted
- “Expand PPM”
Response: Accepted.
- “Modulation at coding and physical layers are mixed”
Response: Rejected. We believe the note gives clear explanation of the modulation on each layer.
- 4.4.3 should be 4.4.2.1; 4.4.4 should be 4.4.2.2
Response: Accepted.
- SANA registries for SCIDs for new frequencies, mods to S/C registry, new service site
Response: Accepted.
- “Any patents?”
Response: Accepted. Words will be added to clarify that no relevant patents are known.

Other remarks of the annotated PDF can be addressed at Agency Review.

Coding & Sync Sublayer - Recent Activity (1/3)

- Comments from Gian Paolo
 - TC Transfer Frames are generated sporadically, so you can't request a sequence of TC Transfer frames as input

Response:

Use idle sequence when no Transfer Frame is available, in order to maintain contiguous transmission

- TC Transfer Frames are not limited to 64 bits; they can be up to 8192 bits

Response:

Include slicer between data link layer and coding layer, and apply an attached sync marker (ASM) to the frames

- Use “codeword” instead of “codeblock”

Response: The change has been made

- “Codeblock synchronization marker” is actually a “Start Sequence”

Reponse: CSM is appropriate word

Coding & Sync Sublayer - Recent Activity (2/3)

- The statement "A CSM together with a randomized codeword is a Communications Link Transmission Unit (CLTU)." is very questionable (wrong at least for the TC Coding Book)

Response:

Here is the issue I suspect Gian Paolo is getting at. In RF, the CLTU comprises a Start Sequence (a sync marker), a variable number of codewords, and a tail sequence. The new LDPC codes allowed in the RF uplink spec can omit the tail sequence, so the CLTU is a Start Sequence together with one or more codewords.

In the HPE optical book, there is no need for a tail sequence and we use only one codeword in the CLTU, so the CLTU is simply the sync marker and one codeword.

If necessary, we can pick a new term for the entity consisting of the CSM + 1 codeword, but calling it a CLTU is makes sense.

- Your references [4] and [5] shall become only one (possibly the published new TC Coding Book when Agency Review will start).

Response:

Correct. Once the TC pink sheets are approved, there will be only one reference to the TC book.

Coding & Sync Sublayer - Recent Activity (3/3)

- For the downlink the service correctly mentions the Quality Indicator but the books defines no procedure for frame validation.

Response:

The channel decoder provides frame validation (it knows when it succeeds or fails). We can add a sentence to this effect in the book. This is similar to the situation in the RF book for LDPC codes.

- Terms ASM and SMTF should be used instead of DTF

Response:

This change to SMTF has been made. ASM will be used when slicing is needed. CSM will be used for code sync marker.

- For both downlink and uplink nothing is mentioned about the operations at the receiving end.

Response:

Frame validation at the downlink receiver is mentioned now.

Coding & Sync Sublayer - Book Update Summary

- Statement of Intent updated to CCSDS format
- Section 1.1 (Purpose) wording updated to match Physical Layer wording
 - Accounts for de Cola comments on “free space”
 - Accounts for Shames comments on application areas of the standard (space-to-space not precluded)
- Section 1.2 (Scope) reworded
- Section 1.4 (Rationale) updated, to include more detail
- Section on patents has been added
 - LDPC codes are used
 - But no specific patents are claimed for this Recommended Standard
- Section 2.1 (Architecture) minor wording update
- Section 2.2 (Summary of Functions)
 - The functions are laid out more clearly now
- Section 2.3 (Internal organization of downlink sublayer) – New section
 - Sending end
 - Receiving end, including frame validation and synchronization
- Section 2.4 (Internal organization of uplink sublayer) – New section
 - Sending end
 - Receiving end
- Section 3.13 (Frame validation) – new section added
- Section 4.1 (Slicer) – description of slicing TC Transfer Frames
- Annex A:
 - Added SANA considerations
 - Added patent considerations

DSOC Use Case for HPE – Downlink

	CCSDS HPE	DSOC
Channel code	SCPPM	SCPPM
PPM orders	4, ..., 256	16, 32, 64, 128
Code rates	1/3, 1/2, 2/3	1/3, 1/2, 2/3
Repeat factor	1, 2, 3, 4, 8, 16, 32	1, 2, 4, 8, 16, 32
Interleaver	Many lengths allowed	Handful of lengths, amounting to 2-3 s.
Pulse width (ns)	1/8, 1/4, 1/2, 1, 2, 4, 8, 512	0.5, 1, 2, 4, 8
Wavelength	44 wavelengths in ITU grid, 1530 – 1565 nm	Channel 34 (1550.12 nm)
Other physical characteristics	Linewidth, spillover, polarization, jitter, extinction ratio, etc.	Compliant with spec.

DSOC Use Case for HPE – Uplink

	CCSDS HPE	DSOC
Channel code	LDPC	LDPC
PPM orders	2	2
Code rates	1/2	1/2
Interleaver	Optional	Not used
Pulse width (ns)	65,536	65,536
Wavelength	1070, 1064, and 1030 nm	1064 nm (TBR)
Other physical characteristics	Linewidth, spillover, polarization, jitter, extinction ratio, etc.	Compliant with spec.



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Approval Conditions: Barkley

- Erik Barkley (Approve with Conditions):
 1. This may be more of a question than a condition, but filed as condition pending further input: it seems odd to have a book going to agency review when the patent considerations section is indicated as "To be supplied." I think the agencies would appreciate knowing if there are patent considerations as part of the agency review. The statement is ambiguous and can be read as "yes, there are and they are forthcoming" -- if they are known why not state them for agencies to be aware of?

Response: Condition #1 accepted. There are no known patents relating to the specification. Words will be added to state that no relevant patents are known relating to this specification.
 2. Similarly for SANA considerations -- it does not seem like there is anything in particular that needs to be registered, so perhaps indicate "none" or indicate what it is that gets registered so that the agencies are aware/have been informed?

Response: Condition #2 accepted. See response to Shames's condition #3 for more information.

Approval Conditions: Burleigh

- Scott Burleigh (Approve Unconditionally): No conditions, but two comments.
 1. On page 2-1, the reader might wonder how it is possible to assess the correctness of this document in the absence of rationale, which will only be provided in a future informative document; some explanation would be appropriate.

Response: The sentence stating that a future informative document will provide the rationale was added by the CCSDS Secretariat. WG agrees that a future informative document (Green Book) will provide the rationale for the various choices made in the specification. Without this sentence, the rationale is exactly the same as the 131.0-B-2 book.

2. On page B-1, security might be provided at the application and/or transport ****and/or network**** layer.

Response: This change will be made to the security annex. Even better, the suggestion of de Cola will be used, to simply state that security will be handled by layer(s) above the physical and synchronization and coding layer.

Approval Conditions: de Cola (1/2)

- Tomaso de Cola (Approve with Conditions):

1. The book deals with optical communications: why not stating that is about free-space optical communications, since optical communications (e.g., LiFi) could be used onboard spacecraft or on planets to link rovers and landers (for example)?

Response: Condition #1 accepted. A statement will be added to section 1.1 stating that it relates to free-space optical communications. We already state that the specification is targeting space-to-ground and ground-to-space, but we are not opposed to adding “free-space” to the description. (Li-Fi is also free-space, but we take the point – onboard communications is a different thing than the spec we are proposing.)

2. Section 2.2 states that one of the objectives of the book is to define the center wavelength. As a matter of fact, the center frequency (from which wavelength in vacuum can be derived) is the first objective (see section 3 and subsequent).

Response: Condition #2 accepted. Section 2.2 will be updated to state that the book defines the center frequency (not the center wavelength).

3. Section 1.1 states that the specification deals only with space-to ground and ground-to-space. Could it be explicitly stated that space-to-space is beyond the scope of this release of the book?

Response: Condition #3 rejected. The spec only relates to space-to-ground and ground-to-space communications. Correct, it does not apply to other scenarios, including space-to-space, but it is too much to ask the book to explicitly disavow all things it is not. If this remains a concern, however, it can be addressed during agency review.

Approval Conditions: de Cola (2/2)

- Tomaso de Cola (Approve with Conditions):
 4. Section B.1.1 states that security is provided by upper layers, indicating transport and application layers as those eligible for it. In my view, SDLS is also to be considered. Without entering the jungle of all possible protocols providing secure communication, the brackets and the indication of transport/application layer could be simply removed.

Response: Condition #4 accepted. The security section will be updated to remove references to specific layers, and will simply state that security will occur at layer(s) above the physical and synchronization and channel coding layers.

5. No clear if there are patent implications to be provided in the next release or there are none.

Response: Condition #5 accepted. Words will be added to clarify that there are no known patents relating to the specification.