**SLS C&S Working Group**
**Minutes of the Meeting**

CCSDS Spring 2024 technical meetings were held from November 4th to 8th in London, UK.

The C&S WG convened two days, on November 6th and 7th, for the following meetings: C&S, joint C&S/SLP/RFM, joint C&S/SLP/RFM/SDLS, and joint C&S/RFM.

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# C&S meeting

The C&S meeting was held on November 6th.

## Opening of C&S activities

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| --- |
|  |
| **Reference** | N/A |
| **Presenter** | C&S chair |
| **Inputs** | * [agenda](https://cwe.ccsds.org/sls/docs/SLS-CandS/CWE%20Private/Meeting%20Materials/2024/2024%20-%20Fall/SLS-CS-agenda-Fall%202024_final.pdf)
* C&S [status presentation](https://cwe.ccsds.org/sls/_layouts/15/WopiFrame.aspx?sourcedoc=%7B93BF6CE4-223F-4801-9C67-6BFADB7895F0%7D&file=CS_status_Fall2024.pptx&action=default&CT=1731068077842&OR=DocLibClassicUI)
 |
| **Minutes** | Agenda was presented.Issue of the limited manpower and travel budget of ESA/ESTEC (see [Spring 2024 MoM](https://cwe.ccsds.org/sls/docs/SLS-CandS/CWE%20Private/Meeting%20Materials/2024/2024%20-%20Spring/SLS-CS%20Spring%202024%20MoM_iss1r0_clean.pdf)) for CCSDS activities is still present and monitored. As done for the past meeting, ESA-ESTEC representatives in C&S and RFM will inform immediately in case they are unable to attend Spring 2025, for ensuring that WGs can continue activities as planned. |

## Final edits to add TF slicing to the “TM coding” blue book

|  |  |
| --- | --- |
| **Reference** | SLS-CS\_24-17 |
| **Presenter** | K. Andrews/NASA |
| **Inputs** | * [presentation](https://cwe.ccsds.org/sls/docs/SLS-CandS/CWE%20Private/Meeting%20Materials/2024/2024%20-%20Fall/inputs/SLS-CS_24-17%20%28TM%20slicing%29.pdf)
* [pink sheets of 131.0-B (TM BB)](https://cwe.ccsds.org/sls/_layouts/15/WopiFrame.aspx?sourcedoc=%7B01AD7950-D8E4-4827-B5C4-F9F2C1C1EFF1%7D&file=SLS-CS_24-17%20-%20Annex%20-%20CCSDS%20131.0-B%20with%20slicing%20and%20turbo%20interleaver_ia_ksa.doc&action=default&CT=1730109991109&OR=DocLibClassicUI)
 |
| **Minutes** | Input for AI\_24\_01 and to reply comments received by SLS AD, following request for Agency review.Comments were reviewed, agreed, and implemented during meeting directly in the [Pink sheets](https://cwe.ccsds.org/sls/_layouts/15/WopiFrame.aspx?sourcedoc=%7B2A4A70AE-4B3E-40C5-987A-9EC2E8CEC21D%7D&file=SLS-CS_24-17%20-%20Annex%20-%20CCSDS%20131.0-B%20with%20slicing%20and%20turbo%20interleaver_ia_ksa_jq_ksa_CS.docx&action=default&CT=1731060578939&OR=DocLibClassicUI).The WG resolved that pink sheets (**RES#1**) can be sent for Agency review. |
| **Outputs** | * **RES#1**, to send Pink Sheets of 131.0-B for Agency Review.
* [Pink Sheets](https://cwe.ccsds.org/sls/_layouts/15/WopiFrame.aspx?sourcedoc=%7B2A4A70AE-4B3E-40C5-987A-9EC2E8CEC21D%7D&file=SLS-CS_24-17%20-%20Annex%20-%20CCSDS%20131.0-B%20with%20slicing%20and%20turbo%20interleaver_ia_ksa_jq_ksa_CS.docx&action=default&CT=1731060578939&OR=DocLibClassicUI) of 131.0-B
 |

# Joint C&S/SLP/RFM meeting

The meeting was held on November 7th.

## CCSDS 211.1 Pink Sheet (Proximity-1 RFM) and CCSDS 211.2 Pink Sheet (Proximity-1 C&S)

|  |  |
| --- | --- |
| **Reference** | SLS-CS\_24-13, SLS-CS\_24-14 |
| **Presenter** | N. Maturo/ESA |
| **Inputs** | * [RFM supporting presentation](https://cwe.ccsds.org/sls/_layouts/15/WopiFrame.aspx?sourcedoc=%7B9F1D3B38-9EBA-4293-9696-F3A1EB5096E1%7D&file=SLS-CS_14-13_RFM_Pink.pptx&action=default&CT=1730114518920&OR=DocLibClassicUI)
* [RFM pink sheets](https://cwe.ccsds.org/sls/_layouts/15/WopiFrame.aspx?sourcedoc=%7BC67532E4-B532-4BA1-AD12-6BF44A2EDD1D%7D&file=SLS-CS_14-13_RFM_Pink_ANNEX.doc&action=default&CT=1730116145742&OR=DocLibClassicUI)
* [C&S supporting presentation](https://cwe.ccsds.org/sls/_layouts/15/WopiFrame.aspx?sourcedoc=%7B352EFC2C-C94F-423C-B321-1C5466510B94%7D&file=SLS-CS_24_14_CeS_Pink.pptx&action=default&CT=1730114497389&OR=DocLibClassicUI)
* [C&S pink sheets](https://cwe.ccsds.org/sls/_layouts/15/WopiFrame.aspx?sourcedoc=%7B46CA0E2A-2808-44FA-A322-3B97CD8DFB3F%7D&file=SLS-CS_24_14_CeS_Pink_ANNEX.docx&action=default&CT=1730116134058&OR=DocLibClassicUI)
 |
| **Minutes** | Presentations gave latest updates in Proximity-1 C&S and RFM pink sheets for introducing S-Band extension. During meeting:* ESA confirmed (AI\_24\_14) that phase noise mask is considered at RF output. As such, it was agreed to remove the word “oscillator” from the specification in 4.2.3, and rephrase it as “transmitter phase noise”;
* Hailing modulation index was set to pi/3 rad-pk (60 degrees). It was also agreed to specify all modulation indexes in rad-pk instead of degrees;
* Modulation index 0.2 was removed from the list of possible indexes, in favor of 0.0 rad-pk. The latter allows a “No-modulation mode” (carrier only when w/o ranging) that can be commanded through the Directive;
* Differently from [Spring 2024 agreements](https://cwe.ccsds.org/sls/_layouts/15/WopiFrame.aspx?sourcedoc=%7BC4FBE243-1ED3-4FDF-98F6-B5B5AF017C47%7D&file=SLS-CS%20Spring%202024%20MoM_iss1r0_clean.pdf&action=default) it was decided to apply filtering to Bi-Phase-L data format also for when doing Hailing (for meeting the SFCG mask when Bi-Phase-L/PM is used). In particular:
	+ The Spring 2024 agreement was initially due to ESA Lunar Pathfinder (LPF), with the intention of minimizing the loss on the hailing channel;
	+ ESA performed a second check with LPF and confirmed that filtering is actually acceptable also for the hailing.
* the 255-bit pseudo-randomizer was made normative, since already adopted by LPF, while the usage of the 17-cell randomizer was excluded (since deemed as not required);
* Maximum symbol rate was increased to 4096 ksps, in harmonization with UHF, and in favor that is a power of 2 of the minimum symbol rate (1 ksps);
* Upon CNES proposal, it was agreed to add a figure that clarifies the ‘1’ and ‘0’ voltage transitions versus advance/delay of the modulated-signal phase.

As follow up it was agreed:* NASA (D. Lee and S. Rodriguez, **AI\_24\_17**) to provide a proposal for including PN ranging parameters in the RFM Blue Book (if feasible with the current status of PN ranging activities for space-to-space);
* N. Maturo/ESA to provide an update of the Pink sheets based on the meeting discussion (**AI\_24\_18**);
* By mid-December, the two pink sheets to be distributed to the WGs, and to have a meeting by mid-February for possibly releasing the sheets for Agency Review.
 |
| **Output** | * **AI\_24\_17**
* **AI\_24\_18**
* Agreement to have a mid-February progress meeting (remotely)
 |

## Byte alignment ambiguity in Prox-1 with LDPC coding

|  |  |
| --- | --- |
| **Reference** | SLS-CS\_24-18 |
| **Presenter** | K. Andrews/NASA |
| **Inputs** | * [Presentation](https://cwe.ccsds.org/sls/docs/SLS-CandS/CWE%20Private/Meeting%20Materials/2024/2024%20-%20Fall/inputs/SLS-CS_24-18%20%28Prox-1%20byte%20alignment%29.pdf)
 |
| **Minutes** | With reference to 211.2-B-3, when using LDPC coding, the standard is not sufficiently clear if TF must be byte-aligned with LDPC codewords or not. As such industry is building HWs for lunar missions that can prevent inter-operabilityTwo possible corrigenda were given, for ensuring or preventing byte alignment.The WGs eventually resolved to have a technical corrigendum (**RES#2**) for including byte alignment in the 211.2-B-3.Chair will prepare technical corrigendum for SLS AD (**AI\_24\_19**). |
| **Outputs** | * **RES#2**, technical corrigendum for byte alignment in 211.2-B-3;
* **AI\_24\_19.**
 |

## Recap on S-Band proximity-1 activities, AoB

|  |  |
| --- | --- |
| **Reference** | N/A |
| **Presenter** | A. Modenini/C&S ChairG. Kazz/SLP Chair |
| **Inputs** | * C&S [status of activities](https://cwe.ccsds.org/sls/_layouts/15/WopiFrame.aspx?sourcedoc=%7B93BF6CE4-223F-4801-9C67-6BFADB7895F0%7D&file=CS_status_Fall2024.pptx&action=default&CT=1731068077842&OR=DocLibClassicUI) presentation
* SLP default session control and directives [word files](https://cwe.ccsds.org/sls/docs/Forms/AllItems.aspx?RootFolder=%2Fsls%2Fdocs%2FSLS%2DCandS%2FCWE%20Private%2FBooks%20in%20production%2FS%2DBand%20Proximity%2D1%20SLP&FolderCTID=0x012000439B56FF51847E41B5728F9730D7B55F&View=%7BAE8FB44C%2DE80A%2D42CF%2D8558%2DFB495ABB675F%7D)
 |
| **Minutes** | Recap of S-Band proximity-1 activities was given:* It was emphasized the target of having the Proximity-1 blue books published by January 2026, that requires an Agency Review by February 2025;
* Since there was no work on possible Ka-Band extension for Proximity-1, this will be dealt as separated project if required. Interested member agencies can send inputs in future CCSDS technical meetings.

G. Kazz/SLP chair presented latest version of SLP default session control and directives. Minor discrepancies with Proxy-1 RFM and C&S pink sheets were corrected directly in the word files.A major concern was raised M. Cosby/UKSA about the inter-operability between Proximity-1 and LunaNet: it was observed that Directives cover only Proximity-1, and that SFCG allocations differentiate between S-Band proximity-1 and other kind of links, thus preventing the inter-operability, target of LunaNet.Issue and way forward was discussed in SLS plenary: reader can refer to SLS plenary MoM.Member agencies are also invited to coordinate with LunaNet representatives in their organizations. |
| **Outputs** | * Updated [Default Session Access control and Directives](https://cwe.ccsds.org/sls/docs/Forms/AllItems.aspx?RootFolder=%2Fsls%2Fdocs%2FSLS%2DCandS%2FCWE%20Private%2FBooks%20in%20production%2FS%2DBand%20Proximity%2D1%20SLP&FolderCTID=0x012000439B56FF51847E41B5728F9730D7B55F&View=%7BAE8FB44C%2DE80A%2D42CF%2D8558%2DFB495ABB675F%7D) for S-Band proximity-1.
 |

# Joint SLP/C&S/RFM/SDLS meeting

The meeting was held on November 7th.

## Security risk of adaptive coding and modulation in Space systems

|  |  |
| --- | --- |
| **Reference** | N/A |
| **Presenter** | Oxford University via SDLS WG |
| **Inputs** | * Presentation
* Other [supporting documents](https://cwe.ccsds.org/sls/docs/Forms/AllItems.aspx?RootFolder=%2Fsls%2Fdocs%2FSLS%2DCandS%2FCWE%20Private%2FMeeting%20Materials%2F2024%2F2024%20%2D%20Fall%2Finputs%2FSecurity%20Risk%20of%20ACM%20%2D%20supporting%20material&FolderCTID=0x012000439B56FF51847E41B5728F9730D7B55F&View=%7BAE8FB44C%2DE80A%2D42CF%2D8558%2DFB495ABB675F%7D)
 |
| **Minutes** | Presentation from Oxford University about potential vulnerability in ACM system was given. The results presented are derived from the study in the paper “Security Risks of Adaptive Coding and Modulation in Space Systems”, of Edd Salkeld et al, presented at the ESA security conference in 2024.The CCSDS WGs recognize the potential flaws of ACM, and will investigate the following levels of protection:* Uplink of TCs for changing the ACM;
* Protection of SNR estimator for deriving the channel condition;
* Replay of downlink.

Activities will be coordinated by SDLS WG. |
| **Outputs** | * SDLS will review the VCM, SCCC, and DVB-S2 blue books, and report to C&S, RFM, and SLP on required changes for protecting the ACM from potential attacks.
 |

## Joint C&S/RFM

The meeting was held on November 7th.

## Link Budget Digital Format – status update (with demonstration)

|  |  |
| --- | --- |
| **Reference** | SLS-CS\_24-16 |
| **Presenter** | A. Modenini\ESAN. Maturo\ESAA. Mourglia\TAS-I via ESA |
| **Inputs** | * [Presentation](https://cwe.ccsds.org/sls/_layouts/15/WopiFrame.aspx?sourcedoc=%7B759AEC47-0263-4E27-8F12-09DE59DA1EF1%7D&file=SLS-CS_24-16%20-%20LBDF%20-%20status%20update.pptx&action=default&CT=1730116645117&OR=DocLibClassicUI)
* [UML and XSD files](https://cwe.ccsds.org/sls/docs/SLS-CandS/CWE%20Private/Meeting%20Materials/2024/2024%20-%20Fall/inputs/SLS-CS_24-16%20-%20Annex%201%20-%20LBDF%20XSD%20and%20UML.zip)
 |
| **Minutes** | Status of activities was presented.Demo, for showing the benefits of having a LBDF, was given. |
| **Outputs** | * Esa will continue activities as normal work, with target of having draft Orange Book in Spring 2025.
 |

## Demonstration of new link budget method based on random draws

|  |  |
| --- | --- |
| **Reference** | SLS-CS\_24-15 |
| **Presenter** | H. Guillon/CNES |
| **Inputs** | * [Presentation](https://cwe.ccsds.org/sls/docs/SLS-CandS/CWE%20Private/Meeting%20Materials/2024/2024%20-%20Fall/inputs/SLS-CS_24-15_CCSDS_Fall_2024_link_budget_demonstration.pptx?d=w0e9d03527ef143e586bf56b1ccc18805)
 |
| **Minutes** | Topic is re-called from Spring 2025 presentation where an alternative method for computing statistical link budget was given.Presentation is informative, no proposal to change currents standards.Demo was provided. Member agencies interested in using the tool can contact CNES. |

# C&S WG Status

This section provides highlights of C&S activities, based on the presentation given at end of meeting, that can be found in [CWE](https://cwe.ccsds.org/sls/_layouts/15/WopiFrame.aspx?sourcedoc=%7B93BF6CE4-223F-4801-9C67-6BFADB7895F0%7D&file=CS_status_Fall2024.pptx&action=default&CT=1731068077842&OR=DocLibClassicUI).

## Projects

Currently C&S WG is working on the [following projects](https://cwe.ccsds.org/fm/Lists/Charters/DispForm.aspx?ID=32):

* *TM synchronization and coding – new channel interleaver for Turbo codes*
* *Proximity-1 extension*
* *Slicing of Transfer Frames*
* *Link Budget Digital Format (LBDF).*

and has one project proposal on hold (due to limited manpower):

* *VCM Greenbook.*

## Resolutions

The WG had two resolutions:

* **RES#1**, to send Pink Sheets of 131.0-B for Agency Review;
* **RES#2**, technical corrigendum for byte alignment in 211.2-B-3.

## Action Items status

AIs list was reviewed. Latest status is reported in Annex.

# Annex 1: Action Item List

Open action items are listed in the table below.

AIs closed during this meeting are cancelled out in the table below (with traceability about their closure).

The new AIs are those starting from **AI\_24\_17**.

Latest version of AI list can be found on CWE (private folder, requires login): <https://tinyurl.com/jyrjpz6a>

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **AI#** | **Action** | **Actionee** | **Due date** | **Status** | **Traceability** |
| **AI\_23\_08** | Provide an update of 130.1-G (TM GB), in preparation of 2025 reconfirmation, for including the following:* Use of TM codes in Ground-to-space links;
* Compatibility with USLP;
* 17-cell randomizer;
* Turbo channel interleaver;
* Transfer frame slicing.

Book captain: J. Quintanilla/ESA | J. Quintanilla/ESA, A. Modenini/ESA, N. Maturo/ESA, K. Andrews/NASA | Spring 2025 | Open |  |
| **AI\_23\_13** | Review draft VCM GB ToC and provide feedback to C&S chair on whether to proceed with development of the GBNOTE: during Spring 2024 project was decided to be put on-hold, and action kept open for Fall 2025. | All | Fall 2025 | Open |  |
| **AI\_23\_18** | ~~Modify text in the draft 211.2 Prox-1 Data Link Layer Blue Book to explicitly indicate that slicing will be used, instead of partitioning as stated in the current draft.~~ | ~~N. Maturo~~ | ~~Spring 2024~~ | Closed | SLP latest doc |
| **AI\_23\_20** | ~~Include specification of the filtering of the bi-phase signal in the draft update of 211.1 Prox-1 Physical Layer Blue Book based on the pink Recommendation 2.4.7A~~ | ~~N. Maturo~~ | ~~Spring 2024~~ | Closed | SLS-CS\_24-13 |
| **AI\_23\_22** | ~~Update the spurious emissions mask in Figure 5-3 of the draft 211.1 Prox-1 Physical Layer Blue Book to be in-line with the spurious lines resulting from filtering of the bi-phase signal~~ | ~~N. Maturo~~ | ~~Spring 2024~~ | Closed | SLS-CS\_24-13 |
| **AI\_24\_01** | ~~To provide consolidated pink sheets for Agency Review of 131.0-B with following editorial edits (on top of those already presented at Spring 2024):~~* ~~Note about codeblock (for RS only) under figure 3-1 and 3-3~~
* ~~Review title of Section 3.3~~
* ~~Reinstate CADU~~
* ~~Make randomization mandatory (Review Figure 2-2, 2-3, and Sections 4.2.2, 5.2.1, 7.2.1, 8.2.2, and 10.x).~~
 | ~~K. Andrews~~ | ~~June 2024~~ | Closed | SLS-CS\_24-17 |
| **AI\_24\_02** | To provide Draft Yellow Book for the two prototypes of the Turbo channel interleaver | J. Quintanilla | Spring 2025 | Open |  |
| **AI\_24\_03** | ESA/NASA to: * cross check results about CLTU termination performance (with tail and idle sequence) for identifying the reason of the discrepancy between the two analyses
* in case issue is confirmed, to check if also LDPC(256,512) has same problematic
 | K. AndrewsA. ModeniniN. Maturo | Spring 2025 | Open |  |
| **AI\_24\_05** | ~~To check the need of having an EVM requirement in the Proximity-1 211.1-B, or if this can be considered a specification at unit level~~ | ~~C&S/RFM WGs~~ | ~~July 2024 (intermediate C&S meeting)~~ | Closed | No inputs in favour  |
| **AI\_24\_06** | ~~To draft CWE project for an update of 414.0-B (PN ranging), with the objective of adding space-to-space and one-way ranging~~ | ~~D. Lee~~ | ~~July 2024~~~~(intermediate C&S Meeting)~~ | Closed | [CWE project](https://cwe.ccsds.org/fm/Lists/Projects/AllOpenChartersWithDraftProjects.aspx) |
| **AI\_24\_07** | ~~To check rationale in LNIS for having modulation index range 0.2-1.4, since 0.2 and 1.4 appears not practicable cases~~ | ~~S. Rodriguez~~ | ~~May 2024~~~~(before intermediate C&S meeting)~~ | Closed | SLS-CS\_24-13 |
| **AI\_24\_08** | ~~To provide an updated list of modulation index (in deg) to be supported, taking into account that LPF uses pi/3, and (possibly) input by LNIS (see AI\_24\_06)~~  | ~~N. Maturo~~ | ~~July 2024~~~~(intermediate C&S Meeting)~~ | Closed | SLS-CS\_24-13 |
| **AI\_24\_11** | ~~To assess possible incompatibilities of the current S-Band directives for a possible extension to Ka-Band~~ | ~~M. Cosby~~ | ~~July 2024~~~~(intermediated C&S meeting)~~ | ~~Closed~~ | Superseded by inter-operability activities discussed at SLS plenary (see SLS MoM) |
| **AI\_24\_12** | ~~To review UML diagram for LBDF for checking parameters to add/remove.~~ ~~NOTE: Member agencies can contact ESA as needed since there is not yet documentation available, with the exception of Section 1,2,3 in the draft Orange Book.~~ | ~~C&S WG~~ | ~~Fall 2024~~ | Closed | SLS-CS\_24-16 |
| **AI\_24\_13** | ~~To add non-normative note about having as input bistream instead of TFs, as will be done in 131.0-B-6~~ | ~~C&S chair~~ | ~~After Agency Review of 131.0-B-6 for TF slicing~~ | Closed | Superseded, note was removed in agreement with SLS AD |
| **AI\_24\_14** | ~~To verify that:~~ * ~~S-Band phase noise mask provided was measured at RF output of LPF,~~
* ~~Doppler dynamics of 75 Hz/sec is the worst-case scenario of a lander.~~
 | ~~N. Maturo~~~~A. Modenini~~ | ~~Fall 2024~~ | Closed | SLS-CS\_24-13 |
| **AI\_24\_15** | ~~To repeat analysis for UHF taking into account mask an Doppler as provided in 211.1-B, with the objective to see if same challenges in the synchronization are also for UHF links at low rates~~  | ~~W. Lee~~ | ~~Fall 2024~~ | Closed | Email A. Modenini on 30rd July 2024 to NASA – note will be added as part of AI\_24\_18 |
| **AI\_24\_16** | ~~ESA (and other member agencies) interested in contributing to the project of space-to-space and one-way ranging (with activities or a prototype) to inform RFM Chair~~  | ~~ESA and other member agencies~~ | ~~Fall 2024~~ | Closed | See RFM MoM |
| **AI\_24\_17** | To provide a proposal for including PN ranging parameters in the Proxy-1 RFM Blue Book (if feasible at current status of PN ranging activities | D. LeeS. Rodriguez | **2nd December 2024** | New |  |
| **AI\_24\_18** | To update draft pink sheets of Proxy-1 RFM/CS with the following:* Add default parameters for hailing (including UHF), by setting MI=pi/3 rad-pk (both) and 8 ksps uncoded (for UHF);
* To enforce 255-bit randomizer;
* To enforce filtering for Bi-phase-L for S-Band in all cases (including hailing)
* To add figure for clarifying ‘1’ and ‘0’ voltage transitions;
* to remove MI 0.2 rad-pk, and add MI 0 rad-pk, in the list of S-Band MIs;
* to increase S-Band max sps to 4096 ksps
* to add note about issues in synchronization at low rate also for UHF (as done for S-Band)
 | N. Maturo | **15th December 2024** | New |  |
| **AI\_24\_19** | To prepare technical corrigendum for 211.2-B-3 for having byte alignment, and send to SLS AD | A. Modenini | **2nd December 2024** | New |  |

# Annex 2: list of participants

**NOTE**: participation list is only for C&S members. It does not account additional participants from RFM, OPT, SLP WGs in joint meetings.

|  |  |
| --- | --- |
| **Name** | **Affiliation** |
| Amanuel Geda | DLR |
| Andrea Domenica Mourglia | ESA |
| Andrea Modenini | ESA |
| Clement Leclerc | CNES |
| Daniel Pettitt | ESA |
| Dennis Lee | NASA |
| Eric Pitts | NASA |
| Greg Kazz | NASA |
| Gunther Sessler | ESA |
| Herve Guillon | CNES |
| Jean-Luc Issler | CNES |
| Jorge Quintanilla | ESA |
| Kenneth Andrews | NASA |
| Klaus-Juergen Schulz | ESA |
| Marie Vialard | CNES |
| Massimo Capozzi | ASI |
| Nicola Maturo | ESA |
| Romina Fenker | ASI |
| Shannon Rodriguez | NASA |
| Stefano Petri | ESA |
| Victor Sank | NASA |
| Wai Fong | NASA |
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| Xavier Enrich | Eumetsat |